Lessard, Edward T

From: w. molzon [wmolzon@uci.edu]
Sent: Friday, January 23, 2004 2:07 PM
To: Travis, Richard J
Cc: Alforque, Rodulfo; Glenn, Joseph W; Iarocci, Michael; Kane, Steven F; Kroon, Peter J; Lessard, Edward T; Mortazavi, Payman; Rehak, Margareta L; Sidi-Yekhlef, Ahmed; Wu, Kuo-Chen; Makdisi, Yousef I
Subject: RE: LESHC 04-02, MECO Spec Electronic Review - Transmittal of Committee Comments

Hi Richard, In reference to our phone conversation of an hour ago, I have arranged that Peter Wanderer will get you a copy of the latest version of the memo about the risk of ozone accumulation.
Peter Yamin tells me that Myron Strongin from BNL concurs with the statement in the memo that a conservative upper limit on the thickness of ozone that might adhere to the wall of the tubing is 8 molecular layers. We will ask him to review our memo and write a comment on it. I will forward the concerns about ODH to Brad Smith and he can comment on the protection that the cryostat provides in the event that there is a leak in the nitrogen tubing that traces the heat shield. Regards, Bill

W. Molzon
Department of Physics and Astronomy
University of California
Irvine, CA 92697-4575

Phone: 949 824 5987
Fax: 949 824 7478
wmolzon@uci.edu

-----Original Message-----
From: Travis, Richard J [mailto:travis@bnl.gov]
Sent: Friday, January 23, 2004 9:28 AM
To: 'molzon@bnl.gov'
Cc: Alforque, Rodulfo; Glenn, Joseph W; Iarocci, Michael; Kane, Steven F; Kroon, Peter J; Lessard, Edward T; Mortazavi, Payman; Rehak, Margareta L; Sidi-Yekhlef, Ahmed; Wu, Kuo-Chen; Makdisi, Yousef I; Travis, Richard J
Subject: LESHC 04-02, MECO Spec Electronic Review - Transmittal of Committee Comments

Bill,

Thank you for the opportunity to review the "Statement of Work and Technical Specification for the Design, Fabrication, Installation and Test of the MECO Superconducting Magnet System Revision (Draft 3.0)". The detailed comments from several Laboratory ES&H -Cryogenic Safety Subcommittee members are attached below. Our major comments are:

1) The potential for ozone buildup in liquid nitrogen and a possible explosion hazard are unresolved issues. (See Woody Glenn's comments below.) Perhaps an experiment involving irradiated liquid nitrogen is in order, or you might consider using helium gas or liquid xenon in lieu of LN2 for this application. We feel that the information you have provided thus far, that is, designing the heat shields so that they can only cool with liquid nitrogen, would risk having the design rejected by the Cryo-sub Committee. For our part, we have decided to meet with a group of subject matter experts and to develop actions that you may wish to follow so that this can move forward. Yousef Makdisi is pulling together the group of experts and he will let you know the results soon.

2) As input to our ODH Calculations, the Cryo-sub Committee needs the failure rates that are associated with the heat shields. Since these are unique designs, the designers need to provide these failure rates to us. We feel that standard failure rates from tables (e.g., <https://sbms.bnl.gov/standard/16/1605e011.htm>) will not do in this case.

Please feel free to contact Ed Lessard (X4250) or me (X 5827) with any questions that you might have.

Rich Travis

LESHC Secretary

Lessard, Edward T

From: Kane, Steven F
Sent: Tuesday, January 20, 2004 6:27 PM
To: Travis, Richard J; Mike Iarocci (E-mail)
Cc: Lessard, Edward T
Subject: RE: LESHC 04-02, MECO Magnet Draft SOW/Spec Review

MECO Magnet SOW and Tech Spec ...

My comments are attached. I put in something about heat load analysis, but Mike can do a better job of describing it than I. Also, Ralph Brown should be able to provide the seismic specs

-----Original Message-----
From: Travis, Richard J
Sent: Tuesday, January 13, 2004 7:13 PM
To: Alforque, Rodulfo; Glenn, Joseph W; Iarocci, Michael; Kane, Steven F; Kroon, Peter J; Mortazavi, Payman; Rehak, Margareta L; Sidi-Yekhlef, Ahmed; Wu, Kuo-Chen
Cc: Lessard, Edward T; Ellerkamp, John J; Greves, Linda E; Travis, Richard J
Subject: LESHC 04-02, MECO Magnet Draft SOW/Spec Review

All,
Ed asked me to followup and to let everyone know that we would like your comments by COB Tuesday 1/20. Please send your input to me, with a copy to Ed. Thanks, Rich

-----Original Message-----
From: Lessard, Edward T
Sent: Thursday, January 08, 2004 11:46 AM
To: Kane, Steven F; Wu, Kuo-Chen; Glenn, Joseph W; Iarocci, Michael; Travis, Richard J; Kroon, Peter J; Rehak, Margareta L; Mortazavi, Payman; Sidi-Yekhlef, Ahmed; Alforque, Rodulfo
Cc: 'wmolzen@uci.edu'
Subject: FW: MECO Magnet Draft SOW/Spec

Hi Folks:

Please look at this Design Spec for the MECO Superconducting magnet. I believe the Cryogenic Safety Committee asked to be involved at the design spec phase so here is your opportunity to speak up if you see anything you interesting.

Thanks.

Ed

DRAFT

Statement of Work
and
Technical Specification
for the
Design, Fabrication, Installation and Test
of the
MECO Superconducting Magnet System

Revision Draft 3.0

Prepared by

Bradford A. Smith

Plasma Science and Fusion Center

Massachusetts Institute of Technology

Cambridge, MA 02139

Date: November 12, 2003

1. INTRODUCTION

The Muon-to-Electron Conversion Experiment (MECO) seeks to detect muon to electron conversion, providing evidence that the conservation of muon and electron type lepton number can be violated. Observation of this violation would suggest physics beyond the Standard Model. The experiment is to be installed in the Alternating Gradient Synchrotron (AGS) facility at Brookhaven National Laboratory (BNL), Long Island, New York.

During this experiment, a high energy proton beam produces pions when it hits a heavy target inside the 1.5 m diameter by 5 m long Production Solenoid (PS). A fraction of the muons resulting from pion decay are captured in the 0.5 m diameter bore by 13 m long, S-shaped Transport Solenoid (TS), which contains collimators, providing sign and momentum selection. The muons are stopped in a target inside a 1.9 m bore by 10 m long Detector Solenoid (DS) that houses detectors to measure the energy of the conversion electrons. Magnetic field is controlled to 5 T ±5% at the high-field end of the PS and to 1 T ±0.2% in the detector region of the DS. Detection is at the unprecedented level of 2 conversions in 10^{17} stopped muons.

2. SCOPE

This document identifies those work items and requirements applicable for the design, fabrication, installation and test of the MECO magnet system.

The MECO Magnet System Conceptual Design Report (CDR) is considered a reference design document. The Subcontractor, when designing and fabricating the MECO Magnet System, may use any or all parts of the reference design. Whether the Subcontractor chooses to follow or modify the reference design, the Subcontractor assumes responsibility for meeting the subcontract requirements.

3. APPLICABLE DOCUMENTS

3.1 Binding project documents

Documents listed below shall be binding requirements on the Subcontractor. Also, verify each is cross referenced in the appropriate section of the SOW where it is applicable. This still needs to be done.

3.1.1 MECO Magnet Field Specifications, May 11, 2001, W. V. Hassenzahl.

This needs to be updated for PS and DS fringe field effects.

3.1.2 PS Magnet Iron Specification

This needs to be written. This spec should be written to capture the nuclear shielding requirement, if that is the primary purpose of this iron. Also, this spec needs to identify any special field shaping requirements imposed on the magnet iron to control fringe fields from the PS magnet into the muon path through the TS. As written, the magnet SOW of this document requires that the Subcontractor provide the PS iron.

3.1.3 DS Magnet Iron Specification

This needs to be written. This spec should be written to capture the cosmic ray shielding requirement, if that is the primary purpose of this iron. Also, this spec needs to identify any special field shaping requirements imposed on the magnet iron to control fringe fields from the DS magnet into the muon path through the TS. As written, the magnet SOW of this document requires that the Subcontractor provide the DS iron.

Check with Tracey/Mike: If part of a document is invoked, do we reference it as binding or non-binding? For example, several of the MECO documents on the web page (e.g., MECO-MuonBeam-03-002: WBS 1.5.2) contain the best present definition of interface requirements, along with a host of other info that is not directly relevant for the magnet. What do we do with these? Cite the relevant sections only? For now they are left in the non-binding category. Ultimately, the interface documents should stand on their own and be binding.

3.1.4 Facility layout drawing

This will be a binding document and must be provided by BNL.

3.2 Non-binding project documents

3.2.1 MECO Superconducting Solenoid System Conceptual Design Report, June 6, 2002

3.2.2 SSC Cable Test Data, (DELETE AND MOVE TO RFP)

SSC cable test data is included as Appendix B. Note: leave intact until completed.

3.2.3 MECO Construction Project DRAFT Management Plan, Version: June 21, 2001 (or latest version of this document in effect at the time of contract placement). (DOES THIS HAVE DIRECTION OR INFORMATION – I AM THINKING IT SHOULD BE AN RFP DOCUMENT FOR INFOR)

3.2.4 Tables of SSC Inner and Outer cable spools and lengths set aside for the MECO Project. (DELETE AND MOVE TO RFP FOR INFO)

3.2.5 Magnet Interface Control Documents

The following is listing of current documents available at http://meco.ps.uci.edu/ref_design/ref_design.html:

3.2.5.1 MECO-Standards-03-001: MECO Standard Coordinate System

3.2.5.2 MECO-Target-02-001: WBS 1.3.2 - Heat and Radiation Shield Reference Design

3.2.5.3 MECO-MuonBeam-03-003: WBS 1.5.1 - Muon Beamline Vacuum System Reference Design

3.2.5.4 MECO-MuonBeam-03-002: WBS 1.5.2 - Collimator Reference Design

3.2.5.5 MECO-MuonBeam-03-004: WBS 1.5.6 - Muon Beam Stop Reference Design

3.2.5.6 MECO-MuonBeam-03-005: WBS 1.5.5 & 1.5.8 - Detector Shields and Absorber Reference Design

3.2.5.7 WBS 1.5.7 - Anti-Proton Stopping Window Design Report

3.2.6 BNL Outside Contractor Site Access Document (DELETE /MOVE TO SUBCONTRACT) leave here until move confirmed.

The Subcontractor shall comply with the conditions outlined in the BNL document "Work by Contractors on the Brookhaven National Laboratory Site – Supplemental Conditions", available at http://www.bnl.gov/PPM/suppl.htm.

3.2.7 MECO Safety Plan

(Needs to be written)

3.2.8 MECO Insulation Report, Cryogenic Materials, Inc., March 21, 2003

3.2.9 MECO Management Plan (DELETE – This is not a SOW requirement, can reference in RFP for information if want) Is this redundant with 3.2.3?

A draft copy of the MECO Management Plan is currently available at http://meco.ps.uci.edu/.

3.3 Other documents

The following documents form a part of this specification to the extent specified herein. The issue date shall be the one in effect on the date of bid submittal.

3.3.1 American Society of Mechanical Engineers

Boiler and Pressure Vessel Code

Section II	Material Specifications
Section VIII	Rules for Construction of Pressure Vessels

Section IX Welding and Brazing Qualification

ASME B31.5 Refrigeration Piping

ASME Y14.5M Dimensioning and Tolerancing for Engineering Drawings

3.3.2 American Welding Society (AWS)

A2.4 Symbols for Welding and Nondestructive Testing

A5.9 Corrosion Resisting Chromium and Chromium Nickel Steel Welding Rods

D1.1 Structural Welding Code – Steel

D10.4 Welding of Austenitic Chromium-Nickel Steel

QC-1-88 Certification of Welding Inspectors

3.3.3 American National Standards Institute (ANSI)

ANSI/ASQC C1-1996 General Requirements for a Quality Program

B46.1 Surface Texture

3.3.4 International Organization for Standardization

ISO 9000 2000 Standards

ISO 9001 2000 Quality Management Standard

3.3.5 American Society for Testing and Materials (ASTM)

E493 Testing for Leaks Using the Mass Spectrometer Leak Detector in the Inside Out Testing Mode

E 498 Testing for Leaks Using the Mass Spectrometer Leak Detector in the Tracer Probe Mode

E 499 Testing for Leaks Using the Mass Spectrometer Leak Detector in the Detector Probe Mode

B193 Test for the Resistivity of Electrical Conductor Materials

B577 Test of Hydrogen Embrittlement of Copper

E8 Tension Testing of Metallic Materials

E18 Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

B170 Oxygen-Free Electrolytic Copper Wire Bars

B188 Seamless Copper Bus Pipe and Tube

B187 Copper Bus Bar, Rod and Shapes

B353 Chemical Analysis of Copper (Electrolytic Determination of Copper

B342 Electrical Conductivity by Use of Eddy Currents

3.3.6 American Society for Nondestructive Testing, Specification 1A

3.3.7 Copper Development Association (CDA)

3.3.8 Brookhaven National Laboratory

ESH Standard 1.4.1 Pressurized Systems for Experimental Use
ESH Standard 5.1.0 Non-Flammable Cryogenic Liquids

CDA Standards Handbook, Part 2 (Wrought Products) Alloy Data, CDA Alloy No. 10200.

3.3.9 Lawrence Livermore National Laboratory

MEL95-001817-00 Welding of Stainless Steel Components for Ultra-High Vacuum Environment

MEL95-001818-00 Fabrication and Handling of Components for Ultra-High Vacuum Environment

4. STATEMENT OF WORK

The Subcontractor shall, unless otherwise noted, furnish all labor, materials, equipment and facilities to design, fabricate, assemble, install and test the MECO magnet system in accordance with this specification and statement of work.

4.1 Subcontractor's general responsibilities

The Subcontractor shall design, fabricate, assemble, ship, install, align, commission and perform acceptance testing on the MECO magnet system and the refrigerator/liquefier? in the experimental hall at Brookhaven National Laboratory. In addition, Subcontractor shall provide all required spares, software, reports, documentation and technical data in accordance with the subcontract requirements. Specific services to be provided by the Subcontractor include, but are not limited to, the following:

- Management
- Design
- Fabrication
- Quality Assurance
- Installation
- Acceptance Testing

4.2 Management

The Subcontractor shall provide project management team capable of contract administration support tasks and planning and managing overall project performance. At a minimum, this team shall consist of a Project Manager, Project Engineer(s), Quality Assurance Manager and Production Manager. The Project Manager shall be the central point of contact for the University's technical and procurement representatives. This team shall be responsible for supporting the items listed below.

4.2.1 Key Personnel Listing

At time of award, Subcontractor shall furnish a listing of key personnel, including the project management team identified above, and their functions, together with home addresses and telephone numbers for use in the event of an emergency. Subcontractor shall update the listing as changes occur. The University shall keep this list in confidence.

4.2.2 Correspondence

The Subcontractor shall serially number all correspondence issued concerning the Subcontract and maintain a log. Subcontractor shall include the Subcontract number on all correspondence directed to the University's technical and procurement representatives. Informal e-mails need not comply with this requirement. (NOTE WE NEED TO ID A CENTRAL POC FOR OUR PM &DISTRIBUTIONS)

4.2.3 Project Cost Schedule Baseline

Subcontractor shall update and resubmit the initial cost and schedule baseline established at the time of the proposal if the contract award is deferred, to incorporate and items finalized during the final design activity, or to expand project milestones. This data shall serve as the baseline for all progress reporting, cost reporting, earned value management, any work breakdown structures and payment milestones. The project cost and schedule data shall be capable of being imported by the latest versions of Microsoft Excel and Project, respectively.

4.2.4 Status Reporting

The Subcontractor shall furnish progress reports to the University every month prior to release for fabrication, and every two weeks after release for fabrication. Each progress report shall be in sufficient detail to allow a realistic evaluation of the Subcontractor's progress in meeting all schedule dates. These reports shall summarize unresolved issues and list outstanding Requests for Information (RFIs), Deviation Requests (DRs) and Non-conformance Reports (NCRs). In addition, the reports shall serve ten work day's advance notice of critical witness and hold points during the manufacturing process.

4.2.5 Cost and Schedule Reporting

The Subcontractor shall submit monthly progress reports that discuss the progress of the major activities against the baseline cost and schedule. The reports shall assess the Budgeted Cost of Work Performed and Actual Cost of Work

Performed against the Budgeted Cost of Work Scheduled and provide schedule and cost variances for the month and for the project to date.

4.2.6 Program Reviews

(NEED TO DEFINE MEETINGS TO BE HELD _ QUARTERLY? TO REVIEW STATUS OF PROJECT IDEALLY AT SUB OR KEY SUB FACILITIES).

4.2.7 Property Management

Subcontractor shall manage all government property delivered to its facility or those of its subcontractors.

In addition, Subcontractor shall be responsible for supporting all property management audits, inventories, reporting and recordkeeping requirements in accordance with the subcontract provision TBD.

4.3 Design

Subcontractor shall provide an engineering team capable of managing all engineering aspects of the MECO magnet system to ensure that all aspects of the design, from its interim and final stages, through system acceptance at BNL, move forward in a coordinated, systematic fashion, with minimal risk, and in a manner that meets the requirements of this specification.

4.3.1 Systems Engineering Management Plan

Subcontractor shall submit and implement a plan that documents process controls for key design elements, drawing release, and configuration during design and fabrication to preclude violations of the technical requirements.

4.3.2 Drafting and Drawing Requirements

The Subcontractor CAD software shall have a full 3-dimensional capability, and all assembly drawings shall be integrated from the lower level parts in 3 dimensions with appropriate fit and interference checks.

The Subcontractor shall deliver CAD drawings electronically to the MECO Project in a timely manner, on CD or other appropriate media, as the drawings are created and as needed by the Project.

The Subcontractor shall define a drawing review process (both internal and Project) and release for manufacture, as well as drawing revision control.

Final, as-built, CAD drawings are required on all delivered hardware.

4.3.3 Design milestones

Subcontractor shall identify key design milestones in the project schedule. Milestones shall be organized to show completion of topics planned for the interim and final design reviews. Milestones shall include but not be limited to:

- Plan updates from the proposal

- R&D task completion dates
- Interim design review
- Fabrication specifications complete
- Final design review

4.3.4 Analyses

Subcontractor's design shall integrate the results the key analyses that the subcontractor shall carry out during the design phase. These key analyses include:

- Magnetic analyses coupled with modeling accuracies, material property variances and tolerance studies that are an integral part of the magnetic verification plan (see below).
- 2 and 3D finite element modeling and other structural analyses of all components against the structural design criteria (see below). Analyzed components and assemblies shall specifically include conductor, conductor joints, conductor leads, windings, coil mandrels, cold mass assemblies including welded connections and fasteners, cold-to-warm supports, magnet iron, vessels and vessel-to-experimental-hall-floor supports.
- 3D quench analysis for all magnet systems, with temperature distributions as a function of time evaluated against the quench voltage and temperature requirements. Quench analysis shall be coupled with a coordinated structural analysis of the transient electromagnetic and thermal loads to ensure that the design criteria are not exceeded at any time during quench.
- Heat Load. Analysis shall be prepared to determine the time required to cool down the magnet to operating temperature, Warm up the magnet to room temperature from operating temperature, and heat load while at operating temperature. [ask Mike I. To have a closae look at this.]

4.3.5 Structural design criteria document

Subcontractor shall prepare a structural design criteria document during the design phase on a schedule consistent with the baseline project schedule. Structural design criteria shall be consistent Specification requirements (5.12). As part of the design criteria document, stress/strain allowables for all materials used in the design shall be identified for the temperature range over which the materials will be operated, generally 300 K – 4.2 K.

4.3.6 Recommendation for specific electrical insulation

MECO has invested in a study by industrial experts (3.2.8) who recommended a specific set of insulating materials and methods to be employed to meet the MECO requirements. Subcontractors are requested to follow the insulation materials and methods guidelines presented in this report, unless they can provide compelling evidence to do otherwise prior to or during the final design review.

Subcontractors shall be responsible to defend their choice of insulating materials and methods at the final design review, and be independently responsible for meeting the requirements of this document.

Subcontractor shall provide drawings and procedures for coil impregnation and cure at the Final Design Review.

4.3.7 Magnetic verification plan

The magnetic verification plan shall describe a complete process for integrating the magnetic, structural and thermal design, including the material properties design data base and analytical calculations, with the manufacturing, assembly, installation, and in-process tests, to assure that the final operational magnetic field of the magnet system, following cooldown to operating temperature, will meet the field specification. The thrust of this requirement is for the Subcontractor to demonstrate in advance of final acceptance testing that by maintaining strict control over all processes the magnet will meet the requirements of the magnetic field specification when operated at design current and temperature.

To achieve this, this plan shall be fully integrated with Subcontractor's manufacturing, installation and quality assurance plans.

Subcontractor's plan shall follow the approach below or its functional equivalent:

- Perform an interim magnet system design. The design description shall update the preliminary design description to include current descriptions of the conductor, coil arrangement to meet the field specification, coil insulation system, coil cooling arrangement, joint, bus and lead design, structural solutions and cryogenic system design. Items requiring further verification during final design shall be identified.
- Calculate the margin of the preliminary design's nominal, operational magnetic field at the cold operating temperature to the magnetic field specification over the specified volume.
- Allocate the available margin to all sources of error including those attributable to manufacturing, assembly, installation, cooldown, operation, differences in material properties from those assumed in the design data base, and modeling inaccuracies.
- Assure that the assigned errors can be achieved in the presence of the allowable tolerances.
- Highlight those particular processes whose tolerances have the greatest impact on field margin.
- Identify inspections to be made at the earliest possible time to ensure that the tolerances associated with each critical step are achieved.

Proceed to the next step of manufacturing only after all requirements at the current step are met, consistent with the plan. Each subsequent successful inspection builds confidence that the fabrication is proceeding according to plan.

- Iterate this process until self-consistent results are achieved throughout.
- Support the plan with a complete 3-D structural and magnetic analysis.

4.3.8 Quench detection circuitry calibration plan

The Subcontractor shall submit a quench detection calibration plan as part of final design documentation. This plan shall outline the approach to be followed to set up and calibrate the quench detection system once all magnets are installed in the operating facility and cooled to operating temperature.

4.3.9 Refrigerator/liquefier functional requirements and specification

The Subcontractor shall provide functional requirements for the refrigerator/liquefier (R/L) such that it will properly interface with the Subcontractor supplied control cryostats, valve boxes and all distribution lines, including connections between the R/L and the control cryostats and between the control cryostats and the magnets. The functional requirements shall include specifications for the following:

- the compressor return-side pressure and temperature,
- liquefaction requirement (l/hr) for the vapor cooled leads individually and in total,
- refrigeration requirement (W) at the compressor return-side pressure and temperature,
- a flow schematic of the Subcontractor’s helium system design, including the refrigerator/liquefier, control cryostats, valve box(es), and the magnets, and
- helium state (pressure, temperature, and quality) identification at the key points in the system.

4.3.9.1 Minimum boil-off goal

The magnet system and interfaces to the R/L shall be designed for reasonable (not excessive) cryogen use. It is understood that Tthe largest single 4.2 K heat load in the magnet system be is due to the nuclear radiation heating in the PS cold mass. All other He refrigeration and liquefaction loads shall be driven in the design to a practical minimum. These loads include, but may not be limited, to the conduction loads through the cold-to-warm supports, cryogenic valve lead stems and vacuum separators, joule heating in the electrical joints, thermal radiation loads, and boil-off in the vapor cooled leads.

4.3.9.2 Component locations and helium line lengths

The exact placement of magnets, refrigerator/liquefier components, and control cryostats, will be determined interactively between the Subcontractor, BNL and the MECO project. Generally, the magnets will be inside the shielded area of the hall, while the control cryostats and the refrigerator/liquefier components will be outside the shielded area.

The BNL proposed floor layout will be one of the referenced interface documents. This needs to be completed.

4.3.10 Interim Design Review and Package

The Subcontractor shall prepare an interim design review package for distribution to the review committee 2 weeks prior to the interim design review identified on the baseline schedule. Ideally, the package shall be in the form of an interim design report that includes a detailed description, including drawings, of the key components of the Subcontractor's design. The intent of the interim design review is to enable a timely and independent technical, cost and schedule analysis of the Subcontractor's work, and provide an opportunity for constructive feedback into the design process in a manner beneficial to the Subcontractor and the MECO project.

The interim design review package shall contain at least preliminary descriptions of a significant number of the topics listed for coverage under the final design review activity. Subcontractor's program plan shall identify those topics that will be discussed at interim design review. As a minimum, these topics shall include interim design information on the following.

- Field specification, field matching and projected margin at acceptance testing based on the magnetic verification plan
- Conductor design and margin discussions
- Coil insulation design
- Conductor joint design
- Current lead and bus bar design
- Magnet iron design
- Quench detection systems—primary and backup
- Quench protection system
- Magnet slow discharge
- Power supplies, dump resistors and switches
- Structural design criteria
- Structural analyses
- Warm-to cold-supports

- Preliminary leak rate specifications for vessels
- Cryostat design, including thermal radiation shields and multilayer insulation, integration of the warm-to-cold supports, cryostat gravity supports and vacuum design
- Cryogenic system design, including cryogen flow schematic
- Preliminary refrigerator/liquefier requirements document
- Magnet interfaces to experimental equipment and facility
- R&D plan updates: Subcontractor shall describe all R&D activities required to support the design.
- Specification verification matrix: The Subcontractor shall update its draft specification verification matrix to demonstrate how compliance with each specification requirement shall be achieved. Compliance demonstration can be by analysis, certification, sample testing, or full component or system testing.

4.3.11 Final Design Review and Package

The Subcontractor shall prepare a final design review package for distribution to the review committee 3 weeks prior to the final review design review identified on the baseline schedule. The package shall be in the form of a draft final design report that includes a detailed description, with drawings, of the components of and integrated approach (analysis, R&D and fabrication) to the Subcontractor's design. The Subcontractor shall update the draft final design report based on final review committee comments.

Final design shall include the effects of the magnet iron in the magnetic field analysis, magnetic verification plan, and structural design. The magnetic field analysis shall fully account for the presence of the iron at the design operating current, as well as the hysteresis effect, if any, in the iron through multiple cycles of magnet excitation. The maximum allowable off-center positions of the coils relative to the iron shall be determined and specified by the Subcontractor such they are consistent with the Subcontractor's magnetic verification plan and the structural analysis.

Subcontractor shall submit a final magnetic verification plan at the Final Design Review milestone, supported by a complete 3D structural and magnetic analysis.

All documents, drawings and topics presented at or for the interim design review shall be updated at the final design review.

Specific topics that shall be described in detail at final design shall include but not be limited to the following:

- Field specification, field matching and projected margin at acceptance testing based on the magnetic verification plan
- Conductor design and margin discussions

- Coil insulation design:
- Conductor joint design
- Current lead and bus bar design
- Magnet iron design
- Quench detection systems—primary and backup
- Quench protection system
- Magnet slow discharge
- Power supplies, dump resistors and switches
- Structural design criteria
- Structural analyses of all components
- Warm-to cold-supports
- Acceptable leak rate for all vessels: During the design phase, Subcontractor shall define and defend an acceptable leak rate for all vessels. In any event, allowable leaks shall be no larger than that which results in negligible heat load on cold components from conduction or convection in residual gas when compared with other heat loads on cold structures.
- Cryostat design, including thermal radiation shields and multilayer insulation, integration of the warm-to-cold supports, cryostat gravity supports and vacuum design. Heat loads shall be tabulated for each cryostat.
- Control dewars
- Bore vacuum closures and cryostat-to-cryostat displacements
- Cryogenic system design, including cryogen flow schematic with identification of fluid states
- Draft refrigerator/liquefier requirements document
- Magnet interfaces to experimental equipment and facility
- Magnet manufacturing plan
- Installation plan
- Acceptance testing
- R&D plan updates: Subcontractor shall describe all R&D activities required to support the final design.
- Specification verification matrix: The Subcontractor shall update its draft specification verification matrix to demonstrate how compliance with each specification requirement shall be achieved. Compliance

demonstration can be by analysis, certification, sample testing, or full component or system testing.

4.4 Fabrication (NEED TO ADDRESS FACTORY TEST PLAN) Significant number of items added for this.

Subcontractor shall be responsible for the fabrication of the MECO magnet system and all its components in accordance with subcontract requirements.

4.4.1 Final manufacturing plan

Subcontractor shall update its manufacturing plan as required by the project schedule, but no later than so that it may be included in the final design review package. It shall fully describe the baseline approach to the fabrication of the major elements of the magnet system. Manufacturing approaches shall be described for conductor fabrication, coil winding, coil insulating and impregnation, coil mandrel fabrication, shell fabrication, cryostat fabrication, including thermal conduction and radiation reduction measures, cold-to-warm supports, and the integration of the magnetic verification plan measures. The manufacturing plan shall delineate, down to WBS Level 4, (NOTE: MANUFACTURING PLAN IS AT LOWER WBS THAN MANAGEMENT PLAN –is this a problem UCI to address this) those items which will be manufactured within the Subcontractor's facility, those that will be manufactured by identified Subcontractors, special tooling, and purchased parts. The manufacturing plan shall clearly identify those items, if any, requiring manufacturing release prior to the final design review.

Subcontractor shall notify the University of any proposed changes to the manufacturing plan after the plan is reviewed at final design review.

Subcontractor shall fully integrate his magnetic verification plan with his manufacturing plan to ensure that all components are produced to tolerances that are acceptable for the magnetic field performance of the system.

4.4.2 Fabrication milestones and activities

Subcontractor shall identify key fabrication milestones and activities on the project schedule. Fabrication milestones and activities shall include but not be limited to the following for each magnet (PS, TSu, TSd, DS), as applicable:

- Acceptance of SSC cable, if applicable
- Conductor fabrication tooling complete
- Begin dummy conductor soldering trials, if applicable
- Conductor fabrication release and completion
- First and last coil mandrel fabrication complete
- First and last coil winding complete
- First winding hipot and turn-to-turn short test

- First and last coil impregnation
- Demonstrate dummy conductor joint fabrication
- First and last conductor joint complete
- Cold mass assembly complete
- Helium vessel fabrication complete, if applicable
- Helium vessel leak testing complete, if applicable
- Warm-to-cold support fabrication complete
- First and last warm-to-cold support installed on cold mass
- Thermal radiation shield fabrication complete
- Installation of thermal radiation shield
- Vacuum vessel fabrication complete
- Vacuum vessel leak testing complete
- Cryostat pre-shipment testing
- Ship cryostat

4.4.3 Additional fabrication and testing requirements

All magnet system components, subassemblies and assemblies shall be produced in accordance with the Subcontractor's current manufacturing plan.

Data taken on individual coils from the tests and measurements identified below shall be retained on a coil-by-coil basis in a separate document, each with a unique identification traceable to the specific coil, and shall be available at any time for inspection. Complete test results for each coil shall be a deliverable.

Data taken on each component other than coils shall be recorded on a uniquely identifiable document traceable to the component. Subcontractor shall define the structure for these reports.

4.4.3.1 Conductor

Magnet coils shall be wound from conductors having superconducting strands that are fully continuous, undamaged, and without breaks. Any detected strand damage shall be cause for rejecting that conductor piece length or coil assembly, and the rejected part must be replaced. Subcontractor shall notify the University immediately of any damaged conductor, as well as his proposed replacement length from the provided overage quantity.

Finished conductor shall be checked to ensure envelope dimensions are within acceptable limits.

If Subcontractor’s conductor uses a cable-in-channel design, a dummy length of cable shall be soldered into a dummy length of channel to debug the soldering process prior to the fabrication of actual conductor.

Cables soldered in channels, if used, shall be completely wetted with solder.

Sufficient copper stabilizer shall be used to meet the quench protection requirements.

4.4.3.2 Coil mandrels

Coil mandrels shall be individually checked for compliance with their required dimensions and shapes, required by design and in accordance with the manufacturing plan.

4.4.3.3 Coil winding

Subcontractor shall wind a single pancake for each coil to bring the winding-start lead to the OD of the winding. The balance of the turns shall be layer wound, with the winding-end lead ending at the outer layer. Subcontractor shall place a layer of insulation rated at the full ground insulation potential between the lead-out pancake and the balance of the winding. If the turns in the outer layer of the winding do not constitute a complete layer, these outer layer turns shall be evenly spaced along the full axial extent of the winding, with intervening mechanical support. Turns shall be applied in an orderly manner, with no crossovers except at the layer ends.

Subcontractor shall use pre-formed, insulated turn transitions to ensure smooth transitions from layer to layer. The Subcontractor shall identify the materials for these transitions in the Final Design Review. Transitions shall be fabricated such that they present no sharp edges to adjacent insulation.

Conductor winding tension shall be limited and prevented from exceeding the conductor yield stress by a reasonable margin under all winding conditions.

Subcontractor shall employ insulation taping heads designed so that conductor damage or breakage shall not occur because of a failure (including jams) of the taping head.

Subcontractor shall monitor and record the turn count in each coil in an error-free manner during winding. Turns, and fractional turns, shall be automatically recorded and stored in a non-volatile manner such that loss of power does not result in loss of information. The turns counter shall correctly adjust the count in the event that the winding line needs to be reversed, and turns or fractional turns are temporarily removed from the winding. The turns counter shall maintain a correct turn count to an accuracy of 0.1 turn throughout the winding process, including all starts, stops and reversals. Turn count for each coil shall be consistent with the manufacturing plan.

Subcontractor shall monitor and record winding electrical resistance throughout the winding process to help with the timely detection of turn-to-turn shorts. For each coil, resistance shall be correlated with turn count, and total length of conductor applied to the winding at any time. If turn-to-turn shorts are suspected, they shall be verified, documented and repaired before proceeding.

Subcontractor shall test turn insulation in the winding line prior to turn forming over 100% of its surface for voltage withstand at twice the maximum turn insulation voltage plus 1 kV. Any insulation failures shall be repaired and retested prior to proceeding. Locations of repaired areas shall be documented in the traveler.

4.4.3.4 Completed coils prior to epoxy impregnation

Subcontractor shall insulate wound coils from ground consistent with the ground insulation requirements

Completed coils shall be tested for turn-to-turn shorts such that turn-to -turn voltage is everywhere at least as great as the maximum turn-to-turn voltage that can occur during operation, including quench.

Following the application of the ground insulation, coils and voltage tap leads shall be hi-pot tested to 2200 V dc. Leakage currents shall be less than 20 μA.

4.4.3.5 Epoxy impregnation

Epoxy mixing and preparation shall follow the manufacturing plan. Epoxy subjected to improper mixing, handling, heating or pressure at any step of the process shall not be used for impregnation of the windings.

Component weights, temperature, and pressure of the coil, the resin components and the mixed resin shall be carefully monitored. Pressures and temperatures of the resin and the coil shall be continuously recorded through resin mixing, coil evacuation, filling and curing.

Coil lead splice regions shall be adequately protected so epoxy does not flow into areas to later be joined or insulated by alternative means.

Whether the subcontractor follows the recommended insulation system (3.2.8) or develop their own, the following requirements shall be met:

4.4.3.5.1. Resin containment and distribution system

The resin containment and distribution system for each coil shall be designed to ensure that the resin fully wets all insulation volumes in accordance with the final design and analysis. Resin void volumes shall be no greater than specified.

4.4.3.5.2. Resin mixing, degassing and transfer protocol

Resin mixing, degassing and transfer protocol, including appropriate temperatures and pressures, shall follow approved and controlled procedures. Resin that has been subjected to improper mixing, temperature or pressure shall not be used.

4.4.3.5.3. Resin volume calculation and measurement

The Subcontractor shall provide a method to insure that the resin volume required in the coil matches the design impregnation volume prior to epoxy cure.

4.4.3.5.4. Sight tube

A means shall be provided at the top of the resin containment system to visually verify the resin level over the coil.

4.4.3.5.5. Alternating pressure and vacuum cycles

A means shall be provided to insure that voids and pockets have been filled prior to epoxy cure. A suggested method is as follows.

When the initial transfer of resin to the coil is complete, and the resin has reached the appropriate level in the sight tube, transfer shall stop. The pressure in the coil will be raised to at least atmospheric to allow the resin to soak and fill additional voids, as applicable. In no case, once the resin level has been verified to be above the coil, shall the level be allowed to fall below the top of the coil. If the resin level in the sight tube has dropped after a minimum of 20 minutes, vacuum shall be re-established in the coil and resin shall be added to refill the sight tube to the “full” level. This process shall be repeated a minimum of 3 times, or the number of times necessary to reach a condition where the level does not drop after the 20 minute period, whichever is greater.

4.4.3.5.6. No unfilled, epoxy-rich volumes

The impregnated coil shall have no unfilled, epoxy-rich volumes larger than 0.5 cm^3.

4.4.3.5.7. Curing temperature and schedule

The cure time-temperature profile shall be in accordance with the submitted procedure. Resin temperature in the coil shall be monitored and recorded. Violations of the time-temperature profile, including those that may be due to an exothermic reaction, are not allowed.

4.4.3.5.8. Post cure cleanup

Following resin curing and cooling, the coil shall be cleaned and excess epoxy outside the defined coil envelope removed.

4.4.3.6 Cold mass assembly

Structurally interconnected mandrels containing coils constitute the cold mass assembly.

Dimensions of the cold mass shall be verified against the manufacturing plan at each step in the assembly process.

The conceptual design for the production solenoid required axial pre-stress to ensure that axial tension would not develop during a quench event. Coils which require pre-stress for proper structural performance based on the final design shall be checked for this pre-stress in accordance with the manufacturing plan.

4.4.3.7 Quench detection circuitry warm verification

The voltage tap wiring polarity and continuity shall be verified with a low level current in each magnet at room temperature, prior to helium vessel closure, or prior to installation of the thermal radiation shield or multi-layer insulation, whichever is first applicable.

4.4.3.8 Conductor joints

Conductor joints refer to coil-to-coil joints and coil-to-bus joints at each end of the magnet.

The joint fabrication process shall be facilitated by fixtures, clamps and heaters as necessary such that the fabrication process is repeatable and consistent.

Joint soldering shall not melt cable-to-channel solder.

All conductor joints and leads to and from the joints shall be structurally supported against violation of the structural design criteria.

All conductor joints and leads to and from the joints shall be adequately cooled, consistent with the joint temperature margin and conductor fraction-of-critical current requirements.

4.4.3.9 Helium enclosure

The helium enclosure refers to the large volume structure that contains the helium in a bath-cooled magnet. Relative to the CDR design, this is applicable for the PS magnet.

Helium enclosures shall be acceptably tested against Subcontractor’s specified leak rate as identified for all vessels during the design phase.

Surface finishes shall be inspected for compliance with Subcontractor’s design and manufacturing documentation. Use of surface-finished components degraded by any means (including fingerprints and scratches) is not allowed.

4.4.3.10 Multi-layer insulation

Multi-layer insulation (MLI) shall be applied in a total thickness and manner consistent with the design and with the heat load calculations. Crushing or compressing the layers during the fabrication process in such a way as to degrade the effective thermal resistance of the MLI is not allowed.

4.4.3.11 Vacuum vessel

Vacuum vessels shall be acceptably tested against Subcontractor's specified leak rate as identified for each vessel during the design phase.

Surface finishes shall be inspected for compliance with Subcontractor's design and manufacturing documentation. Use of surface-finished components degraded by any means (including fingerprints and scratches) is not allowed.

4.4.3.12 Magnet iron

The Subcontractor shall provide PS and DS magnet iron in accordance with 3.1.7 and 3.1.8, respectively. Magnetization (B vs. H) curves shall be provided on one sample from each heat of delivered iron.

4.4.3.13 Control dewars

The conceptual design included control dewars to regulate the temperature and flow rate of liquid helium to the magnet cryostats. Control dewars, if used in the final design, shall be have all fluid spaces helium leak tested for acceptable leak rates in accordance with the manufacturing plan.

Flow resistance in heat exchanger coils shall be verified by recording pressure drop and flow rate using liquid nitrogen an appropriate fluid. Measured pressure drop and flow rate shall be corrected to reflect the equivalent pressure drop and flow rate for helium at the corresponding design state.

4.4.3.14 Power supplies

Power supplies shall be provided for each magnet circuit in accordance with the specification.

Power supplies shall be tested at rated voltage and current for a minimum of 8 hours. Temperatures of components shall not exceed those allowed by the manufacturer. Power supply regulation and ripple shall not exceed the specified allowable.

Control signals for remote control of the power supply shall be tested for proper operation.

4.4.3.15 Quench detection and protection systems

Subcontractor shall supply a magnet quench detection and protection systems in accordance with the specification.

The quench detection system shall be designed, fabricated and tested to be fully consistent with the Subcontractor's quench analysis to show that the maximum voltages, temperatures and stresses, as allowed by the design criteria document, are not exceeded at any time during the quench transient.

4.4.3.16 Vacuum equipment

Subcontractor shall provide vacuum equipment, including pumps, gages, instrumentation, lines and interconnections shall be provided for each cryostat.

4.4.3.17 Mass spectrometer leak detector and leak testing equipment

Subcontractor shall purchase a mass spectrometer leak detector and two standard calibrated leaks. This equipment and all interconnections shall be used for all cryostat leak testing and delivered with the magnet.

4.4.3.18 Cryostat bore vacuum interconnections

Subcontractor shall provide cryostat bore vacuum interconnections between the PS and TS cryostats and between the TS and DS cryostats in accordance with the specification. These bore vacuum interconnects shall be capable of withstanding all relative displacements between cryostats during all operating modes, including cooldown, all combinations of each magnet being energized or not, normal operation with all magnets energized, quench, and warmup.

4.4.4 Magnet and vessel testing prior to shipping to BNL

The Purchaser or Purchaser's Agent shall be notified at least 10 working days in advance of acceptance testing at the Subcontractor's facility so that Purchaser or his Agent can be sent to witness the tests.

4.4.4.1 Leak testing

Upon completion of the vacuum vessel close-out welding, the Subcontractor shall perform vacuum leak testing of the vacuum jacket in accordance with this specification under the following conditions:

1) Vacuum during the final leak test shall be established using the cryostat vacuum equipment that will be delivered with the cryostat.

2) Close all ports to the LHe compartment. Evacuate the vacuum jacket and perform vacuum helium leak checking of the outer surface of the vacuum jacket.

3) Evacuate, back fill, and pressurize the LHe compartment with helium gas up to 15 psig and hold for 10 minutes while the helium leak

detector is leak checking the vacuum space inside the vacuum boundary.

4.4.4.2 Continuity checks

Demonstrate that all sensors and diagnostic wires are exhibit appropriate continuity when tested from the vacuum feedthrough connector.

4.4.4.3 Hipot test

Perform a final hipot test of the windings and voltage tap wires with 2200 VDC between the coil and the vacuum shell. Maximum leakage current shall be less than 100 μA.

[Why don't we have the Subcontractor perform a cold test and quench test while at his facility? Once things get shipped, it's pretty hard to send them back. Some payment schedule is held to the shipment, so these tests at the vendor's facility prevents that payment if it fails. Also, we pay for power for only one test, and they eat the rest – hard to do once it is at BNL.]

4.5 **Quality Assurance** (QA) (SHOULD WE ID minimum WITNESS & HOLD POINTS for which we want notice) Now addressed (see the list under 4.5.3 Audits and Inspections).

4.5.1 Program Requirements

The Subcontractor shall prepare and implement a Quality Assurance (QA) program covering the design, procurement, inspection, testing, fabrication and installation of the MECO magnet system. The Subcontractor's existing QA program may suffice if it adequately implements the quality requirements specified herein. The Subcontractor's QA program shall be consistent with requirements and guidelines established in ISO 9000 and address the following:

4.5.1.1 Organization: All organizations responsible for procurement and manufacture of the MECO magnet system shall be identified. The duties, responsibilities, and authority of each functional group shall be established and the interfaces between them defined.

4.5.1.2 Procurement Control: Procedures shall be implemented to assure that the Subcontractor's procurement activities are in compliance. All raw materials shall be procured with a material certification. The material of all procured components shall be identifiable. All raw materials and components shall be stored in a controlled area.

4.5.1.3 Process Control, Inspection and Testing: Quality requirements for manufacturing functions and the associated material handling and control, inspection and testing activities, and process equipment identification shall be planned and performed to written procedures. Their results shall be documented.

4.5.1.4 Creation of a Project QA Plan: Subcontractor shall prepare a Project QA Plan that shall be implemented upon receipt of University approval.

4.5.2 Project QA Plan:

The quality assurance plan shall be fully integrated with the Subcontractor's Quality Assurance Program and identify key QA checkpoints for the fabrication, assembly, installation and test of the MECO magnet system and its components.

In addition, the plan shall address processes for reporting deviations, nonconformances, and corrective actions to the University, and for requesting technical information as detailed below.

- Deviations and Nonconformances: Subcontractor shall implement a deviation request (DR) process to disposition and resolve planned departures from drawings, specifications, data, procedures, standards, material, workmanship, dimensional tolerances, records, or qualifications and a non-conformance reporting (NCR) process to disposition any unplanned violation of requirements that has already occurred. Subcontractor shall request the University's acceptance of a deviation or nonconformance by completing the form included herein and sequentially numbering, dating, and submitting it to the University for response.

- Corrective Action Requests: Subcontractor shall implement a corrective action reporting and investigation process (CAR) to determine and address root causes of critical and/or repetitive issues identified by DRs and NCRs. In such cases, and as requested by the University, Subcontractor shall generate a Corrective Action Report (CAR) for University approval. CARs shall be sequentially numbered and dated for record control. Subcontractor shall complete the form with references to relevant DRs or NCRs. Subcontractor's QA Plan shall include controls to ensure corrective actions specified by approved CARs are implemented.

- Requests for Information (RFI): Subcontractor shall implement a request for information (RFI) process to document technical information exchanges. Subcontractor shall initiate technical exchanges with the University by completing the RFI form and sequentially numbering, dating, and submitting it to the University for response.

- For purposes of prioritizing the University's review of this documentation, Subcontractor shall code it in accordance with the following:

  - Routine: Seven days response required
  - Urgent: Three day response required
  - Emergency: 24 Hour response required

- Subcontractor shall maintain logs of all the above documents that list all forms submitted to date and their status.

- No work shall proceed on the proposed deviations, nonconformances or corrective actions prior to receipt of written authorization from the University.

4.5.3 Audits and Inspections:

Quality surveillance inspections and quality assurance program implementation audits by the University do not relieve the Subcontractor of the obligation to implement quality control and assurance measures and to perform inspections to ensure full compliance with the subcontract requirements.

Through any of its authorized representatives, the University may inspect or audit the plant or plants of Subcontractor or any of Subcontractor's Subcontractors engaged in the performance of this subcontract. Inspections may include, but not be limited to, observation of manufacturing operations and quality control milestones. Audits, which may be unannounced, may include, but not be limited to, the following: welder qualification records, weld inspector qualifications, material certifications, leak rate measurements and electrical test data. Accordingly, Subcontractor shall incorporate the applicable inspection and quality assurance requirements contained in this section in its Subcontractors which require compliance with this Subcontract.

The University considers the following key milestones in the manufacturing process. Subcontractor shall provide the University with a two week notice prior to the scheduled date for the first article of each type (PS, TS, DS, as applicable) of the following events:

- Cable soldering into copper channel
- Mandrel fabrication
- Winding line prior to winding
- Winding, in process
- Winding complete, ready for testing prior to epoxy impregnation
- Epoxy impregnation tooling prior to impregnation

- Epoxy impregnation
- Testing after epoxy impregnation
- Joint fabrication
- Cold mass assembly, in process
- Warm-to-cold support attachment
- Cold mass assembly complete
- Helium vessel leak test
- Application of multi-layer insulation
- Thermal radiation shield installation complete
- Vacuum vessel leak testing
- Cryostat ready to ship
- Power supply testing prior to shipping

4.6 List of hardware to be delivered to BNL

Subcontractor shall deliver the following hardware to BNL under this Statement of Work:

- Production solenoid cryostat and supports
- Transport solenoid cryostats and supports
- Detector solenoid cryostats and supports
- Quench detection system—primary and backup
- Quench protection system
- Control dewars for controlling cryogen flow to the magnets from the refrigerator liquefier
- Vacuum-insulated superconducting buses for each magnet
- Vacuum-insulated cryogenic lines
- Magnet power supplies
- Cold-to-warm leads for each magnet circuit
- Warm bus connections between each power supply and each cold-to-warm magnet lead
- Instrumentation and control equipment
- All vessel port closures and blank-off flanges used by the Subcontractor for intermediate and final leak testing.
- Mass spectrometer leak detector and two calibrated leaks

- Cryostat and control dewar vacuum pumps, gages, instrumentation and interconnections

4.7 Installation

Subcontractor shall be responsible for the installation of the MECO magnet system and its components at the BNL. The Subcontractor shall provide all special tooling necessary for the installation and perform or subcontract all installation of all delivered equipment.

4.7.1 Installation plan

The Subcontractor shall submit his magnet installation plan at least 9 months prior to the scheduled delivery of the first magnet to the experimental facility at BNL. The installation plan shall outline the general installation sequence and identify any special handling requirements for the installation, including special site preparatory work. The installation plan shall be subject to approval by the MECO Project.

4.7.2 Installation Milestones and Activities

Subcontractor shall identify on his project schedule key installation milestones and activities. Key milestones and activities shall include but not be limited to the following, for each magnet cryostat, as applicable:

- Acceptance testing at BNL
- Initial cryostat placement on experimental floor
- Interconnection of cryogenic equipment and lines
- Interconnection of instrumentation and control equipment
- Cooldown
- Initial magnetic field testing
- Quench detection system calibration complete
- Final alignment
- Acceptance testing

4.8 Acceptance Testing

4.8.1 Subcontractor shall be responsible for acceptance testing the MECO magnet system at the BNL in accordance with subcontract requirements.

4.8.2 Acceptance of the magnet shall be based on all tests leading up to and including the operation of the full magnet system in the experimental hall at the peak field profile while meeting the field specification. In addition, the proper operation of key magnet system features required in off-normal operation (e.g., primary and backup quench detection and protection) shall be demonstrated.

4.8.3 Acceptance test plan: The Subcontractor shall update the acceptance test plan for the magnet system as necessary prior to the final design review.

4.9 Documentation and Reporting Requirements

Subcontractor shall furnish all documents and reports in accordance with this document and the Documentation Submittal Requirements Matrix.

4.10 Record keeping

Subcontractor shall be responsible for maintaining records of all paperwork generated as a result of this subcontract for a period of not less than five years from the date of final payment.

Subcontractor shall make such documentation available at its facility to designated MECO representatives throughout the subcontract performance period as necessary to support audits, reviews, or inspection and quality assurance activities.

5. SPECIFICATION / TECHNICAL REQUIREMENTS

General Description

The MECO magnet system shall consist of all items required for the full functioning of the magnet system in accordance with this specification, including, but not limited to, conductor fabrication, coil mandrels, support shells and coil support flanges, fully insulated superconducting coils and electrical joints, quench protection voltage taps, PS and DS iron return frames, helium vessels, if used, liquid nitrogen shields, cryostat vacuum shells, PS, TS and DS cryostat vacuum systems, pressure safety relief valves and burst discs, vapor cooled leads, power supplies, room temperature DC bus, cold DC leads, dump resistors, cryogen control dewars, cryogenic valves, cryogenic interconnection piping, quench detection and protection system, instrumentation, controls and readouts, all necessary interconnecting wiring, spares, software and the refrigerator/liquefier.

5.1 General magnet requirements

5.1.1 Independent operation of PS, TS and DS

Each of the PS, TS and DS solenoids shall be capable of independent operation at their nominal full operating current, while any or all of the others are warm and de-energized. This requirement is necessary to facilitate initial testing following magnet installation and maintenance activities.

5.1.2 Expected number of thermal cycles

The MECO magnet system shall have a useful life of at least 6 years. The magnets shall be designed so they can be cooled (and warmed) once per year. The magnets shall also be capable of operating for their full number of magnet energizing cycles over the 6 year period with warm-up to room temperature no more often than once every two years.

5.1.3 Expected number of magnet cycles

The MECO Magnet System shall be capable of a minimum of 30 full excitation cycles per year.

5.1.4 Expected number of electrical interruptions

The MECO Magnet System shall be self-protecting from electrical disturbances originating on the AC electrical supply system. The MECO control system, including the magnet quench detection and protection systems, shall be protected against a loss of electrical power for the time required to slow discharge the magnet system.

Brief electrical interruptions, spikes or dips on the AC power grid may occur as often as once per week in the BNL area. These disturbances shall not cause the magnets to quench or cause a loss of vacuum. These two sentences need clarification from BNL. They are too general for a spec requirement. Extended disturbances require that the magnets discharge in a safe manner. If, inadvertently, these or other effects cause the magnets to quench, the design should allow quench recovery to be rapid, minimizing down time.

5.1.5 Magnet bore vacuum

The PS cryostat warm bore shall carry the weight of the heat shield that surrounds the target and limits radiation exposure to the production solenoid. A detailed interface document needs to be developed for the PS interface to the shield. MECO also needs to clarify whether the TS cryostat warm bore mates with the PS cryostat warm bore or to a separate vacuum insert.

The bore regions of the transport and detector solenoids will be evacuated during the running of the experiment. Any combination of vacuum and/or atmospheric pressure in the cryostat and in the bore shall not cause stress outside allowable limits. The pressure in the clear bore may be cycled frequently (once per week) in order to effect changes to the equipment or repair of the system. Sudden loss of vacuum in the bore shall not cause failure of the cryostat.

The Subcontractor shall provide a vacuum closure between the TS and DS cryostat warm bores. The vacuum closure shall be capable of handling the relative displacements of the two warm bores without loss of vacuum integrity under all design conditions, including cooldown/warm-up, normal operation, quench and operation of individual magnets in any combination.

5.1.6 Requirement to reverse polarity and reduce field

The fields in the three solenoids should be reversible as a system. The field in the detector solenoid, separately, shall be capable of operating at field strength between 60% and 100% of its full design value. An anti-hysteresis loop shall be employed to return the both the PS and DS to the required excitation, if necessary.

5.1.7 Energizing the magnets

The MECO Magnet system shall be capable of ramping from zero to full excitation, defined as that excitation required to reach the magnetic field specified by the field specification, in 60 minutes or less. The MECO Magnet System shall be capable of ramping from full to zero excitation in 60 minutes or less.

5.1.8 Magnet slow discharge

Each magnet shall be capable of being slowly discharged from full current to zero current at the fastest rate that does not induce a quench in any magnet by reversal of the power supply voltage. The slow discharge rate by voltage reversal shall not exceed 1 hour. Also, as a backup to power supply failure, each magnet circuit shall be capable of being slowly discharged through a slow discharge resistor. Slow discharge of each magnet shall occur at the fastest practical rate which does not cause any magnet to quench.

5.2 Magnetic field specification

The magnetic field produced by the MECO magnets in their site-installed, cold (~4.5K), energized state must meet the field requirements identified in 3.1.2.

5.3 Conductor

Conductors, whether furnished from SSC stores or acquired by the Subcontractor, shall meet the following requirements:

5.3.1 Conductor margin requirements

When the magnet system is cooled to operating temperature and energized to operating current to meet the field requirement of 3.1.2, all conductors, busbars and conductor joints shall have a temperature margin of at least 1.5 K, and be at a fraction of critical current no greater than 0.40. These requirements shall be met at each and every location within the winding volume, and also at the joints and superconducting leads, with the proton beam on, and with the nuclear heating in the Production Solenoid at least as great as that given in 3.1.4.

5.3.2 Conductor current

The choice of the conductor currents for the final design shall satisfy the conductor margin requirements (5.3.1) and the Subcontractor's Magnetic Verification Plan (4.3.8).

5.4 Quench protection

The following requirements shall apply to the quench protection system.

5.4.1 Hot spot temperature

The hot spot temperature of the conductor shall be limited to a maximum of 150 K following a quench.

5.4.2 Maximum coil internal and terminal voltage

The maximum voltage within the circuit of windings driven by each power supply shall be limited to 2000 volts. This limit applies both at the room temperature lead connections to the coil and also differentially from any point to any point within the coil/power supply circuit.

5.4.3 Satisfying structural design criteria

Each magnet shall comply with the structural design criteria for all magnet components throughout a quench event. Allowable structural loads, as defined by the Subcontractor's structural design criteria, shall not be exceeded

5.5 Electrical insulation

The electrical insulation for all coils shall be designed to meet the voltage withstand requirements throughout the life of the experiment. The maximum integrated lifetime dose due to ionizing radiation for all insulating materials in the PS windings, joints and leads is 31.7 Mrad, and a significant fraction of the radiation damage comes from high energy neutrons. The radiation environment for the Production Solenoid is further specified in 3.2.5.1. Integrated lifetime dose due to ionizing radiation to the TS (Is this still true? Need to capture requirements in an updated target interface document) and DS are negligible.

All insulation requirements shall be met throughout the operating life of the MECO experiment..

All insulation shall be sufficiently robust to reliably withstand stresses, strains, and local contact loads that will be experienced during winding and other manufacturing operations.

5.5.1 Turn and layer insulation

Turn and layer (if any) insulation shall be designed for two times the maximum voltage stress that might appear during all modes of operation and quench, plus 1 kV. If there is no layer insulation, the maximum turn-to-turn voltage shall be taken to be the maximum layer-to-layer voltage.

5.5.2 Ground insulation

Subcontractor shall size ground insulation for the maximum terminal-to-terminal voltage that can appear across the coil. For consistency with the maximum allowable quench protection voltage with some margin, this design voltage shall be 2200 V.

5.5.3 Insulation mechanical requirements

Insulation mechanical stresses, including those that are induced from the combined effects of cooldown, warm-up, operation, quench, and integrated lifetime radiation dose, shall meet the structural design criteria over the lifetime of the experiment.

5.5.4 Joint and lead insulation

All coil leads and joints shall be insulated with a full thickness of ground insulation.

5.5.5 No bare surfaces

No bare conductor surfaces shall be exposed either to vacuum or to helium, except at the vapor cooled leads.

5.5.6 Tracking distances

Surface tracking distances shall be designed to be greater than 1 inch (25.4 mm) for every 1000 volts of potential difference.

5.6 Winding impregnation requirements

Each coil shall be vacuum impregnated with an epoxy suitable for the voltage and radiation environment of the MECO magnet system.

5.7 Electrical joints

Electrical joints are required between those individual coils which are connected in series to one power supply, and between the winding ends and the superconducting buses that connect to the vapor-cooled current leads.

5.7.1 External to the winding pack

All electrical joints shall be located external to the winding pack. Conductor lengths shall be made in continuous lengths sufficiently long to completely wind each coil without internal splices.

5.7.2 Margin requirements

Each electrical joint shall meet the simultaneous requirements of a minimum 1.5 K temperature margin and a maximum fraction of critical current of 0.40 when carrying transport current to meet the overall field requirement. This requirement shall be met both for coil-to-coil and coil-to-lead joints.

5.7.3 Insulation

Each joint shall be insulated to the full potential withstand requirement of the ground insulation, and shall meet the minimum tracking requirements.

5.7.4 Length

Each joint shall be a soldered lap joint of sufficient length and low enough resistance to meet the margin requirements.

5.7.5 Solder

Joints shall be soldered to ensure electrical integrity over the experimental lifetime of the magnet. Solder resistivity shall be sufficiently low to meet the margin requirements.

5.8 Current leads and bus bars

5.8.1 Vapor-cooled current lead location

To facilitate service and access, vapor-cooled current leads which make the cold (~4.5 K) to warm (room temperature) transition, shall be placed outside the shield walls of the experiment, away from the magnets to which they are connected.

5.8.2 Lead and cold bus bar margin requirements

Bus bars which connect the winding ends to the vapor cooled current leads shall meet the conductor margin requirements.

5.8.3 No intermediate joints

At one end, the bus bar shall be lap-solder-joined to the conductor outside the body of the coil winding with joints similar to those joining adjacent coils. At the other end, the bus bar shall be soldered with a low resistance connection to a vapor cooled lead. No intermediate lap solder joints between the two bus bar ends are allowed.

5.8.4 Insulation and field cancellation

Bus bars carrying outgoing and return current from the same power supply shall be insulated for the full coil-to-ground withstand potential and clamped together over most of their length as to maximize field cancellation and minimize the size of their inductive loop.

5.8.5 Continuous operation for magnet slow discharge period without cooling

Current leads shall be designed to be self-protecting against loss of coolant flow over the slow discharge period of the magnet. This means that during a slow discharge without helium flow, the lead temperature shall not rise above the level that will permanently degrade lead performance from specified requirements.

5.9 Quench detection system

The MECO magnet system contains approximately 150 MJ of stored energy based on results from the Conceptual Design activity, and as documented in the CDR. Proper design, fabrication and test of a quench detection system is imperative to ensure that when a magnet quench occurs, the quench is reliably detected and appropriate protective action is initiated, ensuring safe discharge of the magnet energy. The quench detection system shall be sufficiently robust so as to not cause spurious or false trips of the protection system.

5.9.1 Consistency with the Subcontractor's quench analysis

The quench detection system shall be designed, fabricated and tested to be fully consistent with the Subcontractor's quench analysis. For example, the CDR quench analysis showed that maximum coil temperature, voltage and mechanical stresses remain below allowable values following quench if a quench detection threshold voltage of 0.1 V lasting for at least one second is used as a detection criterion for all coils.

5.9.2 Quench detection and complexity/risk tradeoff

Sensitivity of the quench detection circuitry to valid quench signals can be improved through the used of insulated wires co-wound with each coil's conductor. Voltages from these wires can be used to buck out the inductive component of the coil voltage, leaving only the resistive voltage component to trigger a quench detection/protection action. There is an added cost and an added risk of undesired shorts with this approach. Such an approach shall not be used unless the Subcontractor has clearly shown coil quench cannot be reliably detected without it.

5.9.3 Voltage taps

It is possible no two coils within a single power supply circuit will have the same inductance. The lack of balanced inductances, which might otherwise be used to buck out inductive voltages during a quench transient, makes the problem of quench detection all the more difficult. As a minimum, therefore, if co-wound voltage wires as discussed above are not used, the voltage rise across each individual winding and each individual joint shall be derivable as a differential signal from a set of voltage taps, the number determined by the Subcontractor. This quench detection system shall have sufficient redundancy for the design life of the magnet system. It is recommended each tap have its own reference ground wire that is brought out with the tap as a twisted pair. Each voltage tap wire shall be isolated from its coil connection with a minimum series resistance of a value to be recommended by the Subcontractor. The intent of the isolation is to limit current flow should a voltage tap wire accidentally become grounded. Voltage tap wires shall be insulated and tested to 2200 V.

5.9.4 Transient and inductive voltage protection

Transient and inductive voltages that appear on the voltage tap wires during a quench or any other time shall not damage the Subcontractor-provided quench detection electronics.

5.9.5 Loss of power

The quench detection circuit shall be placed on an Uninterruptible Power Supply (UPS). Upon loss of power, all magnets shall be slowly discharged through their slow discharge resistors. Quench detection shall remain operative throughout a loss of power event. Should any magnet quench, the quench shall be detected, and the coil shall be fast discharged in accordance with the overall quench protection scheme. This means that the quench protection system shall also function under a loss-of-power event.

5.9.6 Backup quench detection system

Subcontractor shall provide a backup quench detection system. The function of the backup quench detection system is to ensure quench is detected and initiated should the primary quench detection system fail to function for any reason.

5.10 Quench protection

The primary function of the quench protection system is to safely remove the stored energy in the one or more of the magnets (PS, TS or DS), should a quench be detected in any magnet.

5.10.1 Magnet safe-discharge function

If a quench is detected in any magnet system (PS, TS or DS), that magnet system shall be discharged (its current shall be decreased to zero) in a timely fashion, consistent with the Subcontractor’s quench analysis, while simultaneously meeting the following constraints:

5.10.1.1 The magnet hot spot temperature shall not exceed 150 K.

5.10.1.2 The maximum voltage within the magnet or across its terminals shall not exceed 2000 V.

5.10.1.3 Stresses within the magnet winding and its support structure shall not exceed values allowed by the structural design criteria.

5.10.2 Sequential discharge requirement

If any magnet can sustain an over-current condition as a result of a quench protection action being initiated within another magnet, then the magnet susceptible to over-current must also be discharged in a timely fashion to both meet the same constraints on itself as listed in 5.10.1, and to prevent the current from exceeding design-specified levels.

5.10.3 Quench protection during loss of power

All quench detection and protection features shall remain fully functional and operative during a loss of power event. Should power be lost more than momentarily, all magnets shall begin to slowly discharge at the most rapid rate possible so as to not cause a quench in any magnet. Should a magnet quench for any reason during a loss of power, that magnet and any magnet meeting the sequential discharge requirement shall be discharged rapidly in accordance with the normal quench protection procedure.

5.10.4 Dump resistor

Dump resistors shall be air-cooled by natural convection so as to provide reliable operation during a loss of AC power.

5.11 Power supplies

The CDR has shown that different magnets must operate at different currents to ensure that conductor operating margins are met and/or to ensure that turn placement offsets during winding do not result in a violation of the magnetic field specifications. Power supplies shall have operating currents, regulation and ripple consistent with the field specification requirements (3.1.1) and the Subcontractor's magnetic verification plan.

5.11.1 Current requirements

Each magnet power supply shall be capable of operating its respective magnet in a steady state condition at 105% of normal operating current, where nominal operating current is defined as the current required for achieving the field specification.

Reverse current is not a requirement on the power supplies per se, but all the magnets, as a system, shall be capable of being operated at full reverse field, which may be achieved by reversing power supply leads.

If, however, reverse magnet currents are required to provide the anti-hysteresis loop (5.1.6) to return the magnet iron to its proper level of residual magnetism to meet the field specification, the associated power supplies shall be provided with reverse current capability directly. In other words, 4-quadrant power supplies shall be provided if needed to meet the field specification repeatedly through multiple magnet excitations and de-excitations.

5.11.2 Voltage requirements

Each magnet power supply shall be capable of charging its magnet load from zero to full operating current in one hour. Each magnet power supply shall have the capability, at anywhere between 0 and 100% current, of applying anywhere from minus 100% to plus 100% of the normal charging voltage to its magnetic circuit load. Voltage reversal shall be available as a means for discharging the magnet current to zero as a normal mode of magnet discharge.

5.11.3 Current and voltage control

Each magnet power supply shall be capable of being operated in either current or voltage control mode to within 0.1% of full range accuracy and stability.

5.11.4 Current ripple

Each magnet power supply shall have a maximum current ripple no greater than 0.1% of full operating current.

5.11.5 Remote control

Each magnet power supply shall be capable of being operated remotely. Power supply voltage and current shall be each controlled remotely by a separate 0-10 V signal.

5.11.6 Interface with the quench detection system

Power supplies shall be fully compatible with the Subcontractor’s quench detection and protection systems with which they must interact.

5.11.7 Power supply bus

Power supply bus shall be provided in sufficient length that power supplies may be located up to 200 feet, one way, (BNL confirmation required) from their respective warm-to-cold lead connections. The bus terminations shall be compatible with the Subcontractor’s warm-to-cold lead warm-end terminations, the Subcontractor’s quench protection system hardware, and the Subcontractor’s power supply terminals. Subcontractor shall provide all interconnecting and fastening hardware.

5.12 Structural design criteria

5.12.1 Pressure Vessels and Pressure Piping

All Vessels shall be designed and analyzed in accordance

with ASME VIII and ASME B31.5, as applicable. {they can use Division 1 or Division 2, and usually use a combination of both. We don’t need to preclude that. Test and fabrication is the subject of another paragraph. This section is just design.)

5.12.2 Magnet structural design criteria

Magnet windings and their support structures shall be designed in accordance with a magnet structural design criteria document developed for use in a US laboratory familiar with magnet design, analysis and construction. An acceptable criteria document is "Fusion Ignition Research Experiment Structural Design Criteria”; Doc. No. 11_FIRE_-esCrit_IZ_022499.doc; February, 1999. This was used for the FIRE conceptual design and is available at WWW.fire.pppl.gov, or from the MECO Project. If this document is not used, equivalent criteria shall be developed and specifically identified, and submitted for review.

5.13 Structural requirements

5.13.1 Consistency with Subcontractor’s structural analysis

The structural design of all deliverables shall be self-consistent with the Subcontractor’s structural analysis and Subcontractor’s structural design criteria.

5.13.2 All modes of operation

All structural design criteria shall be met for all defined modes of operation. These defined modes include:

5.13.2.1 Normal operation

5.13.2.2 All combinations of vacuum and atmospheric pressure in the warm bores of the magnet cryostat

5.13.2.3 Quench

5.13.2.4 Operation during a seismic event (Need BNL input on the appropriate seismic criteria to invoke) [Ralph Brown of BNL is a good source for this]

5.13.3 PS cryostat supports radiation shield

The bore of the Production Solenoid cryostat shall be capable of supporting the weight of the radiation shield, which is approximately 68,100 kg and is distributed as defined in 3.2.5.2.

5.13.4 TS cryostat straight sections support collimators

The bore of each cryostat straight section at the end of each Transport Solenoid shall be capable of supporting a collimator, the designs, masses and center of mass locations of which are summarized in 3.2.5.4.

5.13.5 DS cryostat supports experimental equipment loads

Proton and neutron absorbers shall be supported off the DS cryostat wall, as specified in 3.1.10.6. Other experimental equipment loads need to be identified, e.g., the loads for the calorimeter and tracker, and these need to be captured in the appropriate interface documents.

5.14 Vessel requirements

Vessel components including the cryostat and vacuum jacket, shall be manufactured, inspected and tested in accordance with ASME VIII. In recognition of the non-standard design features of the MECO magnet vessels, a code stamp need not be applied.

Base materials for the vessels shall conform to the Subcontractor's drawings and fabrication specifications, and shall be procured under an ASTM or ASME specification.

5.14.1 Vessel welding requirements

Weld joints shall blend into the adjacent base metal in gradual smooth curves, using acceptance criteria consistent with ASME Boiler and Pressure Vessel Code Section VIII. All welds shall be visually inspected by AWS Certified Weld Inspectors (CWI), Certified Associate Weld Inspectors (CAWI) under the supervision of a CWI, or in-house NDE inspectors trained in accordance with the ASME Code. All final weld inspection shall take place after straightening, realignment, or stress relieving of welded assemblies. [I recommend that you modify the requirements of UG-84 here. It is not possible to perform Charpy tests at 4K – the literature on this is extensive. Standard materials are exempt to 20k. If they want to use other than the exempt materials, then I think we need to talk about this.]

5.14.1.1 Weld design

Unless otherwise specified in the Subcontractor's drawings, or approved by the Purchaser or his Agent, the design of pressure boundary welds shall conform to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 and the component design report. Non vacuum boundary structural welds on low carbon steel (where applicable) shall conform to AWS D1.1.

5.14.1.2 Weld procedures and welder qualifications

The Subcontractor shall fabricate welded vessels only at a facility that has an established weld quality assurance program that establishes written procedures and qualification records as described below. Welding documents identified below shall be submitted as deliverable documentation prior to the shipment of any vessel to BNL. Documents shall be keyed for easy correlation with a specific vessel.

(PARAGRAPHS NEED NUMBERING AND DEFINITION WITHIN A CDRL LIST) see additional sentence added above.

5.14.1.2.1. Weld Procedure Specification (WPS)

A WPS is required for each weld process, and the combination of wire filler and base metal type and size to be used in the construction of this vessel. The format of this procedure shall be equivalent to AWS D1.1 Appendix E.

5.14.1.2.2. Procedure Qualification Record (PQR)

A PQR is required for each Weld Procedure Specification. Each PQR shall be prepared in accordance with ASME Boiler and Pressure Vessel Code or AWS D1.1, and signed by a Certified Welding Inspector, NDE inspector, or qualified QC inspector.

5.14.1.2.3. Welder Qualification Test Record

A Welder Qualification Test Record is required for each welder or welding operator covering each welding process, and shall be prepared in accordance with ASME Boiler and Pressure Vessel Code or AWS D1.1, and signed by a Certified Welding Inspector. Certifications shall indicate that the welder has demonstrated the ability to make sound welds of the same type and position, for the same process and materials, using the same equipment as specifically required for fabrication.

5.14.1.2.4. Weld Inspector Certification

Weld inspectors shall be certified in accordance with ASME Section VIII or AWS QC1-88, as appropriate, for the specific type of testing or inspection being accomplished.

5.14.1.3 Filler Metal Storage

All welding wire and flux (if applicable) shall be stored in accordance with AWS D1.1 or ASME Boiler and Pressure Vessel Code, as applicable.

5.14.1.4 Weld Symbols

Weld symbols on sketches and drawings shall be interpreted in accordance with AWS.

5.14.1.5 Weld Identification

Subcontractor shall maintain records identifying the welders associated with each weldment. Each welder shall be assigned a unique symbol or identification number that cannot be transferred.

5.14.1.6 Weld Filler Metal

Electrodes and filler wire for vacuum boundary welds shall conform to ASME Boiler and Pressure Vessel Code, Section II, Part C.

5.14.2 Tests

5.14.2.1 NDE examination and certification

Non-Destructive Evaluation (NDE) personnel shall be qualified in accordance with ASNT-TC-1A.

5.14.2.2 Proof pressure test

The proof pressure test shall be in conformance with ASME VIII, Division 2.

Sufficient notice of these tests shall be provided to the Purchaser or his Agent to allow the Purchaser's Inspector to witness the tests.

5.14.3 Vacuum vessel requirements

The Vacuum jacket/vessel shall be constructed in accordance with the Subcontractor's drawings and fabrication specifications and the following additional requirements

5.14.3.1 Vacuum Boundary Welds

Weld joints shall be welded so that there are no cracks, crevices or incomplete fusion remaining on the vacuum side of the joint. Within the joint, there shall be no trapped volumes that could act as a virtual leak. There shall be no welds that consist of continuous partial penetration welds on both sides of a vacuum boundary joint. For partial penetration joint designs, the vacuum side shall be continuous and the outside weld shall be intermittent. The skin surface of the vacuum side of the joint shall not be broken or machined.

Weld smoothness shall be sufficient to facilitate cleaning by hand with clean room quality wipe cloth to Mil-Std-1246C level 500 without snagging or tearing the wipe material.

5.14.3.2 Vacuum vessel fabrication Requirements

5.14.3.2.1. Cutting Fluids

The following cutting fluids have been tested for low residual outgassing after high pressure, hot water washing with surfactants. No other cutting fluids shall be used unless specifically approved by the Purchaser or his agent.

Synspar GP IPG Industrial Products Group A Division of Spartan Chemical Company, Inc. 110 N. Westwood Ave, Toledo, OH 43607 (604) 526-0551	Blaser 4000 Strong Swiss Instrument/Belmag Machinery 71A Clipper St Coquitlam, B. C. 1-800-537-8990
Dascool #2227 & #2227B D.A. Stuart Company 4580 Weaver Parkway Warrenville, IL 60555 630-393-0833	Trim-Sol Master Chemical Corp. 501 W. Boundary Perrysburg, Ohio 43551-1263 1-800-537-3365
Cimtech #410 Cincinnati Milacron Corp. Cincinnati, Ohio 45209 513-841-8978	Ecosyn #00SND Fuchs Lubricants Co. Harvey, Ill. 60426 (709) 333-8900
Cimtech #3700 Cincinnati Milacron Corp. Cincinnati, Ohio 45209 513-841-8978	Orion Synthetic #7397-2 Vulcan Oil & Chemical Products 5353 Spring Grove Ave Cincinnati, Ohio 45217 (513) 242-2672
WOCO WS-6500 Wallover Oil Company 1032 Pennsylvania Ave. East Liverpool, Ohio 43920 (330) 385-9336	WISCO #4776\ Wisco P.O. Box 20893 Indianapolis, Indiana 46220 (317) 784-4689

WOCO WS-8065 Wallover Oil Company 1032 Pennsylvania Ave. East Liverpool, Ohio 43920 (330) 385-9336	

5.14.3.2.2. Tool Materials

If any stainless steel weld slag requires removal, it shall be done with a clean stainless steel brush, file, burr, or chisel. Abrasive cutting and grinding wheels are acceptable for use on stainless steel only if they are used exclusively on stainless steel and not contaminated with other material. Abrasive polishing compounds shall not be used.

5.14.3.2.3. Vacuum Sealing Surfaces

All surfaces which interface with a vacuum seal shall have a 0.80 micrometer RMS (32 microinch) finish. All o-ring seal surfaces shall be free of dirt, grit, dust and any other contaminants that would prevent a seal or compromise a high vacuum system. Machining or polishing marks shall run parallel to the o-ring seal.

5.14.3.2.4. O-Ring Surface Protection

O-ring surfaces shall be protected during subsequent assembly, packaging, or shipping operations to prevent contamination or scoring. Type of protection selected shall not leave residues that could contaminate a vacuum system.

5.14.3.2.5. Vacuum Vessel Interior Wall

Final surface finish of all vessel walls exposed to vacuum shall be sufficient to facilitate cleaning by hand with clean room quality wipe cloth to Mil-Std-1246C level 500. This can be accomplished by pre-polishing the construction material prior to fabrication. Leak check acceptance testing shall be accomplished only after any internal polishing or finishing is complete.

5.14.3.2.6. Exterior Painted Surfaces

If low carbon steel is used in a part of the fabricated assembly (such as a support stand) these surfaces shall require preparation, priming, and painting. Paint shall be Sherwin Williams designated Polane paint #63EXL609-4394 (Emeryville, CA 510-658-0877) or Purchaser-approved equivalent.

Painting preparation shall remove mill scale, dirt, rust, grease, oil and foreign matter. Sandblasting, bead blasting, or wire brushing is recommended for surface preparation. Prime with E65A71 Polane

Plus Sealer available from Sherwin Williams, lightly sand with #220 wet dry paper, and apply designated polane paint.

The Purchaser reserves the right to approve surface preparation before all painting.

5.14.3.2.7. Exterior Unpainted Surfaces

Exterior stainless steel surfaces that are not vacuum sealing surfaces shall be bead blasted to a matte finish or electro polished.

5.14.3.2.8. Forming

If brake forming is selected as a fabrication process by the Subcontractor, it shall be followed by a visual inspection of bend points to verify that cracking has not occurred.

5.14.4 Vacuum vessel inspection and testing

The Subcontractor shall perform inspections and tests to assure conformance to this specification.

5.14.4.1 Visual inspection

The minimum inspection requirement for all welds in this specification shall be a visual inspection in accordance with ASME Section VIII or AWS D1.1, as appropriate. Visual inspection shall include a pre-weld check of joint preparation and fit-up, as well as for straightness, alignment and perpendicularity, as specified in the drawing.

5.14.4.2 Leak Testing with a Helium Leak Detector

The Subcontractor shall assign a trained personnel and provide all equipment necessary to perform helium leak testing, which includes helium leak detectors with a dry pump or a diffusion pump with a LN cold trap, calibrated leaks, calibrated sniffer, roughing pump with cold trap, traps, port covers, valves, piping, bellows, connection hardware, gauges, bottled helium, and liquid nitrogen.

Vacuum leak test will be the only acceptable leak checking procedure in the present project. The sniffing method will be used as rough screening when the targeted boundary cannot support a negative pressure in the contained volume. Any inspection with sniffing method shall be re-inspected with vacuum leak test in the later assembly stage.

Alternate leak checking procedures proposed by the Subcontractor shall not be substituted unless specifically approved in writing by MECO Magnet Subsystem Manager.

The checkpoints and the type of helium leak checking during assembly stage shall be defined by the Subcontractor in the fabrication plan and approved by MECO MDMG.

5.14.4.3 Vacuum tests

The following shall be performed in the prescribed order:

1) Evacuate vessel to maximum pressure of 10-3 torr using a dry pump or a LN trapped roughing pump.

2) Leak testing shall be performed with a mass spectrometer leak detector in accordance with ASTM E493, ASTM E 498, or ASTM E 499. Two standard calibrated leak devices (do we want the Subcontractor to provide and turnover to us at test completion? Probably not a bad idea—see 4.4.2.16, where I added this equipment as a deliverable) are required for this test. Both shall have been calibrated within two years of the test, and both shall be used to calibrate the leak detector immediately prior to the leak test. After leak detector calibration, one calibrated leak shall be connected directly to the vessel through an isolation valve, and the other shall be connected directly to the leak detector through an isolation valve. Appropriate valving shall be provided so that the roughing pump and the leak detector can be individually isolated from the vessel.

3) Spot leak checking shall be performed using an external helium source while the leak detector is pumping the vessel.

4) Final leak checking shall be performed by enveloping (bag) the entire vessel in a helium filled enclosure for a minimum of 10 minutes while the leak detector is pumping the vessel.

5) The maximum allowable leak rate shall be 10-8 std atm-cc/second (helium) with all pump effluent to a residual gas analyzer or mass spectrometer leak detector.

5.14.4.4 Sniffing tests

The following shall be performed in the prescribed order:

1) Confirm the sensitivity of sniffer is better than 5 x 10-5 std atm-cc/second helium with a calibrated helium source.

2) Use an appropriate temporary cover to close the vessel / volume, and introduce helium gas into the test volume without cracking the temporary seal.

3) Confirm the background helium reading is below the sensitivity of the sniffer.

4) Spot leak checking shall be performed by inserting the sniffer in the envelope, which covers the outer surface of the joint area.

5) At high background helium count, consider isolating the first envelop from the background with a second envelope, which is flushed with nitrogen gas.

6) Remove leak checking attachments and clean up the surface. Flush out helium gas if necessary.

5.15 Refrigerator/liquefier Specification

The Subcontractor's refrigerator/liquefier functional specification shall be fully integrated with the magnet system's final design requirements and those for the helium and liquid nitrogen systems stated below.

5.16 Helium system requirements

The refrigerator/liquefier (R/L) for the MECO magnets shall provide two phase liquid helium to the MECO magnet system. The cryogenic plant shall be specified to be of sufficient capacity to meet at least 150% of both the refrigeration and the liquefaction requirements, as specified in Subcontractor's final design.

5.17 Nitrogen system requirements (NOTE: This needs to be rewritten to reference requirements and information provided by BNL)

BNL shall supply the Liquid nitrogen. It is assumed that BNL will also provide liquid nitrogen from a bulk storage tank to a central distribution manifold within the experimental hall, and a vapor vent from a central collection manifold in the experimental hall to an outdoor vent. BNL shall identify the location of the central LN2 distribution manifold and vapor vent, and related piping sizes, elevations, etc.

All distribution lines from the BNL bulk supply to the magnet system and from the magnet system to the outdoor vent connection shall be provided by the Subcontractor. LN_2 supply and vapor return manifolds shall be provided by the Subcontractor with appropriately sized liquid and vapor ports, respectively, that will connect with the BNL supplied piping. The Subcontractor's final design shall identify the calculated LN2 boil-off under all modes of operation. Liquid nitrogen usage shall be kept to a practical minimum.

5.18 Instrumentation and Control

Instrumentation and control systems need to be integrated with the I&C for the experiment. Is there an overall I&C plan? Will there be a MECO control room? How and what are signals sent to the central control area? Is there a communication protocol? Who has the lead on this? Note that MECO I&C components will interface not only with its own I&C but also with the RHIC experiment. MECO needs an interface document for this.

5.18.1 Known areas of I&C

5.18.1.1 Quench detection

5.18.1.2 Quench protection

5.18.1.3 Power supply data (voltage, current, control signals)

5.18.1.4 Cryogenic instrumentation (level meters, pressure, temperature)

5.18.1.5 Overall system control scheme for remote control

5.19 Experimental interfaces

Much of this material is written as it was in the original CD RFP. It all needs to be clarified and updated by the Project to the maximum extent possible, ideally through the drafting of WBS-specific interface documents which can be referenced in Section 3 of this document, rather than including the details here, as is largely the case for now.

5.19.1 PS Shield and Clear Bore Vacuum

The bore of the production solenoid will have a production target and a massive heat and radiation shield. These will be supported off the PS cryostat warm bore in accordance with 3.2.5.2 (Interface needs clarification). The PS bore vacuum vessel shall mate to the transport solenoid cryostat, the inner wall of which will serve as the vacuum vessel in the transport solenoid bore; the TS design shall make provisions for mating of the cryostat end wall to the PS bore vacuum to provide a continuous vacuum vessel connecting the bores of the PS and TS. The shield will reduce the heat load on the magnet cold mass to the values given in 3.2.5.2. The conductor temperature margin shall be met in the presence of this heat load.

5.19.2 Incoming proton beam

There shall be provisions in the PS and TS cryostats as necessary for a proton beam entrance channel at the region of the transition between the production and transport solenoids. The proton beam centerline enters the magnet system envelope in a horizontal plane. The proton beam tube has an ID of 80 mm and a 3.2 mm wall thickness. The centerline of the port projects to a point that is approximately 1590 mm to the right of z=0 on the PS axis relative to the field specification coordinates and will subtend an angle of 210 mrad with respect to the PS axis. Small changes in the approach angle of the beam tube relative to the PS axis may be acceptable, but require the approval of the MECO Project. Provisions will be made for a vacuum chamber separate from the TS cryostat vacuum to penetrate the TS cryostat in order to connect the PS clear bore vacuum to the proton beam line vacuum. This vacuum chamber will connect the PS bore vacuum to the proton beam transport vacuum and isolate both from the TS cryostat vacuum. The proton beam line will be limited by both active and passive means to remain within the region of the beam port entrance into the magnet system envelope. The proton beam line configuration is not yet complete. The position and properties of possible nearby magnets and magnetic materials must be provided as part of the final magnet system specification.

5.19.3 Outgoing proton beam and required clear bore access

The outgoing proton beam will exit through a port interior to the strongback. The effects of the outgoing proton beam on the heat and radiation load on the PS cold mass are included in the heat and radiation loads that are specified herein.

The PS cryostat and service ports should not extend inside a radius of 0.75 m. This precludes interference with the proton beam exit and access to the interior of the production solenoid clear bore.

5.19.4 Heat and radiation load on the production solenoid

Interactions of the proton beam with the production target will heat the target to approximately 2200 K; it will radiate about 5 kW of thermal radiation. Most of this will be absorbed by the cylindrical thermal shield consisting of some combination of copper, tungsten and/or depleted uranium. The heat shield will be maintained at ambient temperature by a special cooling system. The shield will reduce the heat load on the magnet cold mass to the values given in 3.2.5.2. The conductor temperature margin shall be met in the presence of this heat load.

5.19.5 Service ports for the production solenoid

The service ports for the production solenoid shall be located in the zone of least radiation, near the transition to the transport magnets. To the extent possible, components that might fail should be located in this region of the cryostat and should be accessible through these ports. The precise location of service ports will be developed in collaboration with the MDMG.

5.19.6 Service ports for the transport solenoid

The service ports for the TS shall be located near the anti-proton-stopping window that separates the bore vacuum spaces of the upstream half of the TS from the downstream half of the TS. Note that this is reworded from the CD RFP.

5.19.7 Service ports for the detector solenoid and vacuum interface

Service ports for the DS shall be in the region between the TS and DS. The precise location of service ports will be developed in collaboration with the MDMG.

5.19.8 Use of cryostat as vacuum vessel for transport and detector solenoids

The inner bore of the cryostat for the DS shall mate with the inner bore of the cryostat for the TS, to form a continuous inner bore vacuum space. This inner bore vacuum space shall be extended to a flange at the end of the DS bore region, so that the vacuum region may be extended by others beyond the DS. The Subcontractor shall provide a vacuum blank-off to mate with the downstream bore flange. The DS and TS bores will be evacuated during data taking. Alternatively, the DS and TS may be operated during initial testing with atmosphere in the bores. Thus, the DS and TS cryostats shall be capable of withstanding all possible combinations of vacuum and atmospheric pressure in their bore regions. The TS bore vacuum shall be provided with a flange and vacuum boundary extension that mates with the PS bore vacuum.

5.19.9 Support of collimators off transport solenoid

The Subcontractor shall make provisions for installation of a collimator in each of the straight sections of the transport solenoid. Collimator geometries and masses are specified in 3.2.5.4. They will be supported off the transport solenoid cryostat.

5.19.10 Vacuum Window

The TS magnet shall be divided into two parts, each centerline of which shall trace an approximate 90-degree arc on a radius of about 2.9 m. A vacuum window will be placed between the two TS cryostats to isolate the upstream and downstream portion of the beam vacuum. TS cryostat designs must accommodate the vacuum window and its mounting hardware, as specified in 3.2.5.7.

5.19.11 Support of experimental equipment off the detector solenoid

The internal components of the detector shall be supported off a set of rails mounted on the DS inner cryostat wall. These rails shall be provided by the Subcontractor. The calorimeter cart, tracker cart, target cart, polyethylene shielding, rails and miscellaneous produce a total local loading at various positions along the rail of 4250 kg and a distributed weight of 6800 kg to yield a total 11, 050 kg.

5.19.12 Steel cosmic ray shield and muon beam dump

Needs coordination with 3.2.5.5 and the cosmic ray shield interface document, which is TBD.

A massive shield will surround the DS to absorb cosmic ray particles, which are a source of background in the experiment. It consists in part of a 0.5 m thick steel box beginning 30 cm from the cryostat wall. The box will be closed at the ends by both magnetic and non-magnetic material. The magnet design and magnetic field analysis shall include the effects of the steel shield. It is desired that the field beyond the end of the DS decrease to below 0.05 T in less than 1 m to improve the performance of the beam dump. Is this still a requirement? There should be no flux return or pole piece material at a radius smaller than the cryostat OD. Subcontractor shall develop the design of the and provide hardware for thie interface to the the muon beam dump in collaboration with the MDMG. Penetrations through the cosmic ray shield will be required for cable and cryogenic service runs. Subcontractor shall locate these penetrations in collaboration with the MDMG. The type of steel, thickness and the minimum length of the box will be specified by the MECO Project and the specific design will be developed in collaboration with the MDMG.

5.20 Facility interfaces

The MECO magnet system shall be installed by the Subcontractor in the AGS facility at Brookhaven National Laboratory. It is assumed that BNL will provide a magnet installation requirements document and drawing of the experimental area, identifying the location of the magnet system, shield blocks, control dewars, power supplies, and electrical and cryogenic distribution centers. The drawing should also identify the overhead crane span, hook height and other limitations, if different than stated below. The installation requirements document and drawing then will be included in the applicable documents section of this specification.

5.20.1 Overhead crane

The BNL overhead crane has a capacity of 40 tons. The crane is capable of making vertical lifts to above 31 feet as limited by the bottom of the bridge, but permanent structures shall not exceed 24' 6", which represents the bottom of the crane cab. Based on the Conceptual Design, it is expected that the MECO magnet cryostats will have individual weights that exceed 40 tons. Therefore, the Subcontractor shall be responsible for providing temporary rigging equipment and labor necessary for magnet installation in the experimental facility.

5.20.2 Electrical interfaces

BNL should identify where power panels will be located within the AGS, and what voltages and current or kva ratings are available.

5.20.3 Cryogenic interfaces

BNL should identify where the LN2 manifold described herein will be located and what volumetric flow rate can be obtained at various pressures at that location.

5.21 Safety requirements

The MECO magnet system shall comply with the MECO Safety Plan.

(This section will be completed following resolution of items from the BNL safety reviews of MECO held June 3, 2003.)

5.21.1 Subcontractor supplied electrical equipment shall be provided in accordance with the NFPA National Electrical code.

5.21.2 Compliance with ASME VIII This isn't even a complete sentence. This is specified elsewhere. What is the requirement here?

5.21.3 Pressure relief valves and burst disks. This isn't even a complete sentence. This is specified elsewhere. What is the requirement here?

5.21.4 There shall be no trapped volume or potentially trapped volume (as from any combination of valve closure) that is not protected by a relief valve of adequate capacity.

5.22 Software

All non-commercially available software used in the Subcontractor's delivered MECO magnet system shall be from a controlled and tested release with a clearly identifiable version number. Each program shall be fully documented, including a detailed description of the program's function, and a listing of the source code(s) in text format that corresponds to the embedded version. The Subcontractor shall maintain a full set of development tools needed edit, compile, link and reinstall the program into an updated executable through the duration of the subcontract warranty period.

5.23

5.24 Spare parts

- The Subcontractor shall supply spare parts to ensure no loss of operation of the MECO magnet system by component failures for one year beyond completion of the warranty period. (WHY NOT ONE YEAR AFTER WARRANTY EXPIRES? IF WARRANTING MATERIALS AND WORKMANSHIP –WHY SHOULD YOU PAY FOR REPLACEMENT MATERIALS DURING WARRANTY? I agree—it has been changed)
- These spares shall include but are not limited to spare o-rings, vacuum seals, fuses, five (5) rupture disks of each pressure rating, liquid level probes, connectors, vacuum feedthroughs and miscellaneous hardware.
- Spare Parts List: The Subcontractor shall submit, at the completion of his final design, a list of spare parts recommended for delivery with the magnet system. The list shall include the following information: part name, part number, quantity required per end item, recommended quantity for spares, manufacturer, manufacturer or distributor's contact information, lead time, shelf life, and any special storage instructions.
- The Subcontractor shall replace any spare parts used through acceptance testing. (NEED TO DISCUSS HOW THIS WILL BE PRICED PREAWARD)

I suggest that the data and certifications to be delivered with the contract items be specified. This should be operating procedures, especially for the refrigerator, certs for pressure vessel materials, Welder quals and inspection documents, and the QA stuff that you are requiring, are just a few that come to mind.

Appendix A

MECO Magnet Work Breakdown Structure (WBS)

(NOTE: THE MILESTONE SCHEDULE IS OUT OF SYCH WITH THIS I think this has now been fixed.)

1.4.1 Design INTERIM & FINAL (NEED TO BREAK OUT PER DESIGN MILESTONES IN 4.4.2. Now see 4.4.3, 4.3.10, and 4.3.11.Also, consider stuff from page 6 slides. These have been added).

1.4.2 PS fabrication
1.4.2.1 Conductor
1.4.2.2 Cold structure (Al shells)
1.4.2.3 Winding tooling
1.4.2.4 Winding + VPI
1.4.2.5 Coil Assembly
1.4.2.6 He Can
1.4.2.7 LN2 Shield + MLI
1.4.2.8 Support rods
1.4.2.9 Vacuum shell and gravity supports
1.4.2.10 Vapor cooled leads
1.4.2.11 Misc instrumentation + cryo lines
1.4.2.12 PS magnet iron
1.4.2.13 Shipping

1.4.3 TSu fabrication
1.4.3.1 Conductor
1.4.3.2 Cold structure (coil mandrels)
1.4.3.3 Winding tooling
1.4.3.4 Winding + VPI
1.4.3.5 Coil Assembly
1.4.3.6 LN2 Shield + MLI
1.4.3.7 Support rods
1.4.3.8 Vacuum can + gravity supports
1.4.3.9 Vapor cooled leads
1.4.3.10 Miscellaneous instrumentation + cryogenic lines
1.4.3.11 Shipping

1.4.4 TSd fabrication
1.4.4.1 Conductor
1.4.4.2 Cold structure (coil mandrels)
1.4.4.3 Winding tooling
1.4.4.4 Winding + VPI
1.4.4.5 Coil Assembly
1.4.4.6 LN2 Shield + MLI
1.4.4.7 Support rods

1.4.4.8 Vacuum can + gravity supports
1.4.4.9 Vapor cooled leads
1.4.4.10 Miscellaneous instrumentation + cryogenic lines
1.4.4.11 Shipping
1.4.5 DS fabrication
1.4.5.1 Conductor
1.4.5.2 Coil Mandrels
1.4.5.3 Winding tooling
1.4.5.4 Winding + VPI
1.4.5.5 Coil Assembly
1.4.5.6 LN2 Shield + MLI
1.4.5.7 Support rods
1.4.5.8 Vacuum can and gravity supports
1.4.5.9 Vapor cooled leads
1.4.5.10 Miscellaneous instrumentation + cryogenic lines
1.4.5.11 DS magnet iron
1.4.5.12 Shipping

SOME OF THESE ITEMS ARE MISSING FROM MILESTONES.
1.4.6 Cryogenic equipment
1.4.7 Vacuum equipment
1.4.8 Power supplies and protection equipment
1.4.9 Installation
1.4.10 Refrigerator/liquefier
These have been added.

Lessard, Edward T

From: Lessard, Edward T

Sent: Wednesday, January 21, 2004 9:30 AM

To: Travis, Richard J

Subject: MECO Spec Document

Hi Travis:

I would like it if the MECO Specification included the following:

For packaging and labeling, all manufactured items sent to Brookhaven National Laboratory shall comply with the Fair Packaging and Labeling Act, TITLE 15 - COMMERCE AND TRADE, CHAPTER 39 - FAIR PACKAGING AND LABELING PROGRAM, see http://www.ftc.gov/os/statutes/fpla/fplact.html

Regards.

Ed

Building 911
P.O. Box 5000
Upton, NY 11973-5000

BROOKHAVEN
NATIONAL LABORATORY

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

date: *January 20, 2004*

to: *E Lessard*

from: *J.W. Glenn*

subject: ***Review of DRAFT Statement of Work and Technical Specification for MECO Superconducting Magnet System.***

I have reviewed the 'DRAFT Statement of Work and Technical Specification for the Design, Fabrication, Installation and Test of the MECO Superconducting Magnet System, Revision Draft 3.0'. I have also looked at other documents from CERN on problems with irradiation of liquid nitrogen [LN].

General comments.

I am not comfortable to have this specification go out without a Cryogenic Safety Committee review. At some point a BNL review will be required and to say no this experiment can not run because it was not properly designed will be a political bomb; to have a major incident if it runs with our approval could precipitate a stand down and a re-review of many C-A cryogenic systems, loosing us possibly a year of operation; as happened with our SEB operation a few years ago. Another option is to have another body do the review and disassociate BNL but if there is a problem we need 'plausible deniability'.

The issue of liquid nitrogen cooling is not addressed in this specification. CERN will allow LN cooling of Aragon at the ATLAS experiment As given in their "ATLAS AOS Agreement On safety EXPLOSION RISK IN LIQUID NITROGEN" [attached] the levels are one thousandth what is anticipated at MECO; also extreme measures are taken, eg.: only 5 PPM of oxygen in the nitrogen. Also they have had a dewar explode at 900 Grey exposure, 18% of the annual exposure for MECO. I suggest that the spec request adequate sized heat shield piping to allow an adequate flow for 'constant' temp for gas He cooling or insulation be adequate for LXe cooling - or provisions be made for some alternately cooled heat shield. The magnet system should not be built so the only feasible way to cool it is with LN. Experimental conformation of various models and calculations would improve confidence, perhaps irradiation of some LN in the desired tubing at UCINRF reactor could be done.

Detailed comments.

Section 4.3 should include:
Rate of failure for the cryogenic containment vessels to calculate ODH classification. These vessels are not ‘standard’ so normal tables of failure rates are not useful.
Leak rate limits from the ‘outside’ and from the ‘warm bore’ volumes during maintenance to prevent excessive oxygen buildup toward a explosion hazard.
Buster disk and relief valve specs and locations.

Section 5.1 should include:
Warm-ups for O3 purges.
Number of quenches allowed.
Thermal capacity of the slow discharge resistors.

Section 5.4: What is the damage to the system if the quench protection system fails – major I expect. Thus a failure rate analysis may be appropriate.

Section 5.5: the reference of 3.2.5.1 does not make sense.

Section 5.9 Include this system in the

Section 5.10: The dump resistor need have adequate thermal mass.

Section 5.11: A spec on voltage ripple would reduce heat load.

Section 5.13: Combined modes should be considered.

Section 5.14; What is the implication of not having a code stamp?

cc: W Meng

		ATLAS AOS n. 12 **Agreement On Safety**
ATLAS Project Document. No. *Project - System -- Type - Sequential No.* **ATC-TY-EY-0018**	*Institute Document No.*	*Created* 20-Jan-2003 / *Page* 1 of 6 *Modified* / *Rev.* **1**

ATLAS AOS
Agreement On safety

EXPLOSION RISK IN LIQUID NITROGEN

Prepared by : **G. Benincasa…..**	***Checked by :*** **G. Benincasa**	***Approved by :*** **Technical Coordinator**

	for information, you can contact :	**G. Benincasa**	Tel. +41.22.767 4278	Fax. +41.22.767 8350	E-Mail Gianpaolo.Benincasa@cern.ch

AOS N. *12*

TIS -ATLAS
AGREEMENT ON SAFETY

1) SYSTEM-SUBSYSTEM-EQUIPMENT CONCERNED

-PBS name…Liquid Argon Calorimeter…..

-Description……Liquid Nitrogen cooling system of the LAr calorimeter………………………………………..

-Ref. Documents…TDR 2- CERN-LHCC 96/11………..

2) SAFETY ASPECTS CONSIDERED

-Short description…Risk of explosions in LN2 exposed to ionizing radiations
……………………………………………………………………….

- Ref. Documents……See Attached note…………………..

3) TIS POSITION

☐ **x** **Agreed(with or without comments)**

☐ **Agreed with restrictions(comments)**

☐ **Rejected(comments mandatory)**

Comments:…Risk is considered as very low, provided that the recommendations in the annexed note are strictly followed……………………………………………..
…………………………………………………………………………

4) SIGNATURES

Date:…22/01/2003……….

TIS	**for TC**	**for the system**
Representative person	**the Glimos**	**Project Leader**
(W. Weingarten)	**(G. Benincasa)**	**(H. Oberlack)**

Explosion Risks in Cryogenic Liquids Exposed to Ionising Radiation

J. Bremer

When liquid nitrogen is exposed to high ionizing radiation the oxygen impurities present in the nitrogen can transform to ozon. A sufficiently high concentration of ozon in liquid nitrogen can lead to an explosion when this ozon re-transforms spontaneously to oxygen.

Article written by Gregory and Nuttall lists a number of explosions that occurred and gives some rough numbers describing the process(CERN TIS-CFM/95-06):

Concentration of ozone in liquid nitrogen formed by transformation of 5000 ppm oxygen under a total radiation dose of 10^4 Gy: $1.65\ 10^3$ mg O_3 / m^3 N_2
(depends on total dose, not on dose rate)

Theoretical minimum O_3 concentration at which an explosion could occur:
4.4 mole% O_3 / N_2

O_3 concentration at which explosion has occurred
5.8 mole% O_3 / N_2

2

<u>What does this figures indicate for the liquid nitrogen volume in the ATLAS cavern:</u>

Total volume of liquid nitrogen present in the cavern under normal circumstances: 10 m^3 (non important figure). This liquid will be circulated through heat exchangers. The heat exchangers will have a total volume of about 0.8 m^3 of liquid nitrogen.

Radiation rate at heat-exchanger level: $5\ 10^1$ Gy/run year;

Initial O_2 concentration in the liquid nitrogen 10 ppm (nitrogen delivery 10 ppm)

Ozon formation depends linear on total dose. In total life time ATLAS we will have $1\ 10^3$ Gy.

Say we will start with the **high** O_2 concentration of 5000 ppm, then we will have in the nitrogen volume after 15 run years $1.65\ 10^2$ mg O_3 / m^3 N_2, equivalent to about
$2\ 10^{-5}$ mol % O_3.

We can thus conclude that even when we take a very high oxygen concentration at the beginning of the experiment (factor 500 higher), we arrive at ozon concentrations which are a factor 10^5 too small to (theoretically) create an ozon explosion.

3

We have however foreseen the following measurements to reduce even further the oxygen content in the liquid nitrogen present in the cavern:

- When nitrogen is filled from a truck into the storage tanks at the surface: nitrogen transfer line between truck and tank will be pumped vacuum before transfer;

- Liquid nitrogen transferred between storage vessel (at surface) and phase separator dewar (UX15 cavern) will pass through liquid Oxysorb filter (such a filter is already in function in the NA48 experiment);

- Once a year the PSD will be warmed up to about 150 K, to be sure that we start the run year with a clean nitrogen storage tank (no accumulation of O_2 or O_3).

4

COMMENTS BY C. Nuttal on 10/1/2003

I have looked at the estimations made by J. Bremer and if the assumptions he made (based on the paper by C. Gregory and myself) are correct then there would be little to fear. However it seems certain that explosions in cryogenic equipment have occurred at much lower doses than that cited by Bremer. M. Tavlet has experienced an explosion in a dewar containing LN2 at a total dose of only 900Gy. In another paper it is recommended that the O2 concentration be kept below 5ppm. The measures that J. Bremer has proposed should be carried out with the addition of:

- Delivery of LN2 to have certified O2 concentration of below 5ppm.
- Written instructions for the the transfer to the CERN Dewar should be drawn up and every operator should be trained to carry out the task exactly as per the instructions.
- There should be an on-line measurement of O2.
- Leaks on the system should be rigorously eliminated as this is one way that O2 can enter.
- Great care should be taken to eliminate mechanical shocks on the cryostat especially at the end of a run.

I am at your disposition for any further help or information you may require.

Regards

Bill

MECO-107
W. Molzon, B. Smith
May 14, 2003
Revised January 7 2004

Safety Considerations of Ozone Buildup in the MECO PS LN_2 System

This is to discuss the possible effects of ozone production in the nitrogen heat shield. The potential problem was first pointed out to us by Wuzheng Meng, for which we are grateful. The concern is that ozone will collect and, when warmed, revert to O_2 in an exothermic reaction that would release significant energy into the LN2 lines that trace the thermal shields. The concern is discussed in the paper of C.R. Gregory and C.W. Nuttall, CERN AT/95-06 (DI), attached as Appendix A.

In discussing some explosion accidents in cryogenics systems, the paper states "It soon became clear that significant quantities of ozone (O_3) were being produced during the irradiation of material samples and that the ozone generation was due to the action of ionizing radiation on the relatively small quantities of dissolved oxygen present in the liquid nitrogen. It appears that shock, local heating or even the presence of solid organic resins such as epoxies can trigger this type of explosion."

Of course, our system is not identical to systems described or referenced in the paper of Gregory and Nuttall. Understanding how our system would react depends on knowing the properties of ozone and its interaction with LN_2. Much information on ozone properties is given in Streng, Journal of Chemical and Engineering Data 6, 1961 (431), attached as appendix B.

Since explosion is a frightening word, it is useful to put this in perspective. First, we note that the explosions referred to only occurred when the ozone concentration in the LN_2 exceeded 4%; as we discuss below, the concentration in the MECO system under any of a number of possible operating scenarios would never exceed 0.04%. Streng reports explosions below this (without details) and apparently only when the fluid is not well mixed and high concentration regions existed. As discussed below, we don't see any scenario in which this can occur in our system. Second, even if the ozone did somehow spontaneously revert to O_2, it is not a personnel safety hazard, or even an issue of damage to the cryostat, or even an issue of rupture of the LN_2 cooling tubes, but only an issue of possible deformation of the heat shield. This itself we cannot tolerate, since it would be a significant loss of it caused a thermal short necessitating repairs.

Relevant to the question at hand is the vapor pressure of the produced ozone and the solubility in nitrogen. Absent some interaction that binds the ozone to the liquid nitrogen, the ozone will exist above the liquid at its saturated vapor pressure at 77 K, reduced by the fractional concentration in the liquid. It will also exist in whatever gas bubbles are produced by the heat transferred from the heat shield to the liquid nitrogen. A paper by Hanson and Mauersberger (J. Chemical Physics 85, 1986 (4669)) gives measurements of the vapor pressure of liquid or solid ozone in the relevant temperature range. It follows the relationship $\log [P/(1 \text{ torr})] = 10.460 - 1021.6/T$. The pressure at 77 K is about 2 mTorr. Most relevant to our situation is the solubility of ozone in liquid nitrogen; Streng reports the solubility to be in the range of 4-5% (molar), measured by a number of groups.

The rate of production of ozone in LN_2 depends on the concentration of O_2 and on the amount of energy deposited. In the range of concentration relevant to us, the rate is given by

$$R(e) = R_o e + (8{,}05 + 1.29 \log e).$$

R is the production rate in units of molecules per 100 eV of deposited energy, R_0 is the production rate in pure O_2 (12.9) and e is the fractional oxygen concentration. This gives typical yields of a few molecules per 100 eV for O_2 concentrations of 10-10,000 ppm. Commercial liquid nitrogen typically has an O_2 concentration of below 10 ppm. We would handle the LN_2 carefully to insure that excess oxygen is not dissolved in the nitrogen, for example by exposing the liquid to a volume of air in the storage dewar.

To give a sense of the size of the problem, consider a concentration of 10,000 ppm O_2, well above what we expect. With a radiation dose rate of 20 μW/gm, 10 kg of LN_2 exposed to that radiation, and 10^7 seconds of running, the total amount of ozone produced is 1.14 moles, about 50 grams. For O_2 concentration of 10 ppm, the amount produced is about half that. The energy released in converting $2O_3$ to $3O_2$ is 3000 J/gm.

We can imagine operating the LN_2 cooling system in a number of ways. In all of these, the nitrogen flows through relatively small cooling tubes that are attached to the thermal shield. Flow is maintained either by pumping or by convection. The typical velocity is about 10 cm/s, assuming cooling tubes with ID=0.5 cm.

1. Method 1 is to operate with a conventional liquid recycling system, venting the gas that is produced during the cooling process and replenishing the LN_2 from commercial tanks as it is evaporated. The oxygen concentration will increase by preferential vaporization of nitrogen. If the oxygen in the produced vapor is at the saturated vapor pressure of oxygen at 77 K, then the equilibrium oxygen concentration in the buffer volume will be higher than the oxygen concentration in the supplied gas by the ratio of the partial pressure of nitrogen to that of oxygen at the operating temperature. That will increase the equilibrium oxygen concentration in the liquid by about a factor of 4, since the saturated vapor pressure of oxygen at 77 K is about 200 Torr.

   Table 1 below is a spreadsheet that allows the calculation of the resulting ozone concentration assuming no ozone is evaporated. For example, if we have a 500 liter (400kg) storage buffer, irradiate a 10 kg mass at a radiation level of 20 □W/gm, run for 10^7 s, and assume the production rate is 2.4 molecules per 100 eV (typical for oxygen concentration of 40 ppm or 4 times a delivered concentration of 10 ppm), we would develop a molar density of a small fraction of a percent in the fully mixed buffer volume. This is well below the saturated solubility of ozone in LN_2. Even if the 10 kg remains in the irradiated region, the ozone concentration is only about 0.14%, well below the level at which it would start to precipitate out as a solid. In fact, the LN_2 is well mixed because of the continuous circulation and we expect the lower concentration to apply.

Total mass [gm]	Irrad. mass [gm]	Rad. [J/s/gm]	ozone prod.rate [mol./eV]	Time [s]	ozone prod. rate [mole/s]	ozone prod. [moles]	ozone conc. [mole %]
4.0E+05	1.0E+04	2.0E-05	0.024	1.0E+07	5.0E-08	0.50	3.5E-03

Table 1. Spreadsheet showing the calculation of the amount of ozone produced in 10^7 running at full intensity.

It is rather easy to monitor the ozone concentration in liquid by fully vaporizing a fraction of the liquid and passing it through an ozone monitor (basically an absorption spectrophotometer). At the end of the running, the ozone-contaminated liquid would be thrown away (vented into the parking lot) and clean LN2 flowed through the system. It could then be verified that no ozone is present in the effluent, to ensure that the system is clean before it is warmed.

Ozone concentrations as small as a few ppm can be readily measured since it has a high absorption cross section for UV light.

2. Method 2 is to operate a totally closed re-circulating system (condensing the returned gas) so that the oxygen level (and hence the highest possible ozone level) can never get above the level in the delivered gas, far below the level at which ozone can condense. Here, we would eventually get to an ozone level of no more than the delivered concentration of oxygen, of order 10 PPM, far below the concentration necessary for it to precipitate out. Periodically, this LN_2 would be thrown away (vented into the parking lot). Again, the ozone concentration in the liquid could be monitored.

3. Method 3 is to operate with a single-pass system; this is the default operation. The cost of this option depends on what fraction of the LN_2 can be vaporized during the pass. Table 3 below is a spreadsheet that allows different assumptions to be tested. The cost of LN_2 is taken to be about $0.07 per liter. The heat load on the nitrogen system for the PS is about 130 W (it is significantly higher in the other magnets). Assuming the exit LN_2 flow has quality 0.5 (50% gas by mass), then the cost per day to vent all the LN_2 that is used to cool the PS is about $10, a negligible cost. In this scenario, the ozone concentration in the system is always negligible. Again, the ozone concentration in the vented nitrogen (gas plus liquid) could be monitored easily.

Nitrogen Flow	Power [J/s]	LN2 frac. vaporized	1/LHV [moles/J]	Flow [moles/s]	Flow [m3/s]	O3 prod. [mole/s]	Outlet Conc. [moles/m3]	cost [$/day]
	130	0.50	1.72E-04	4.47E-02	1.57E-06	6.20E-08	0.0396	9.74

Table 2. The table is a spreadsheet showing the cost of a single-pass option for running the LN_2 cooling system.

These three methods for operating the LN_2 cooling system in a safe way rely on two assumptions.

One assumption is that there is not a small, uncirculated volume of LN_2 in the highly irradiated area, in which a higher ozone concentration is built up, and that this region is not periodically flushed out, and that the ozone does not diffuse into neighboring regions. Hence, it is important to design the LN_2 distribution so that a stagnant region will not develop. Certainly most of the liquid that is irradiated must also be flowing. If not, that region of the magnet would not have its thermal heat shield cooled and the temperature of that region of the shield would increase, LN_2 would be vaporized, and either flow would start or the pressure would rise. It would seem to be difficult to design a system where signification stagnation could develop.

The second assumption is that there is not some anomalous adsorption of ozone on the tubing material. There is no evidence that we have been able to find that there is such adsorption on stainless steel. We can try to estimate how much might occur. Surface scientists with whom we have consulted state that once an adsorbed surface layer is more than a few (3-4) atomic layers thick, the surface has the characteristics of the bulk adsorbed material, and can then be treated as if the substrate has no effect. In that case, bulk solid ozone properties (including solubility in LN_2) would apply. Since the O_3 concentration in the liquid is always very far below the saturated concentration, it would no longer build up. For a very conservative estimate of the amount of ozone that might exist as an adsorbed layer, we assume a 35 Angstrom layer (8 molecules thick) that covers the interior of tubing with an ID of 0.5 cm, about 600 feet long (1 foot of tubing per square foot of heat shield). The calculation of the energy release is given in the spreadsheet below; it is only about 80 Joules, even with the conservative assumptions above.

Density [gm/cm^3]	Atomic #	Avagaodro's number	Atomic Vol [cm^3]	Layer Thick. [Angstrom]
1	48	6.00E+23	8.00E-23	4.31

Calculation of thickness of atomic layer.

Length [feet]	ID [cm]	Thickness [cm]	Ozone Vol [cm^3]	Density [gm/cm^3]	Mass [gm]	Energy [J]
600	0.5	3.50E-07	0.026	1	0.026	78

Gas Vol [m^3]	Pressure [Pa]	R [J/K/mole]	T [K]	Moles	Temp Rise [K]	Press. Rise [Pa]	Press. Rise [PSI]
0.0046	100000	8.4	100	0.55	6.2	6181	0.91

Table 3. The table is a spreadsheet showing a calculation of the amount of ozone that might be adsorbed on the inner surface of the cooling tubing and the amount of energy released if it spontaneously converted to O_2. It also shows the pressure rise in the tubing assuming that the event occurred when the tubing was filled with gaseous nitrogen at 100 K and all the energy went into heating the nitrogen.

This would not be a damage hazard even if it converted to O_2 explosively. Table 3 shows the calculation of the pressure rise in the tubing system, assuming it is closed and filled with nitrogen at 100 K and atmospheric pressure when the event happened. Note that the increase in the number of gas molecules is negligible, since less than 0.001 moles of O_2 are produced, and the volume contains 0.55 moles of N_2.

We conclude that there is more than one way of operating the magnets safely with LN_2 cooling loops tracing the thermal radiation intercept. The default operation mode is simple and inexpensive.

Acknowledgement
We thank Wuzheng Meng for pointing out the phenomenon, for providing the reference, and for useful discussions. We thank Ed Lessard and Wuzheng Meng for pointing out an error in our earlier version.

Appendix A

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN AT/95-06 (DI)
CERN TLS-CFM/95-06

Explosion Risks in Cryogenic Liquids Exposed to Ionising Radiation

C. R Gregory, C. W. Nuttall

Abstract

Explosions in cryogenic fluids were first reported in the early 1950's. Numerous papers have been presented describing these explosions and proposing mechanisms as to their cause. The majority of these incidents have occurred in dewars and cryogenic systems containing liquid nitrogen which have been exposed to ionizing radiation.

It is now widely accepted that the explosions are caused by the very rapid decomposition of ozone, which is formed by the action of ionising radiation on oxygen dissolved in liquid nitrogen.

There is also evidence that oxides of nitrogen are formed and although it is not suggested that these compounds are the primary cause of explosions they do seem to play a catalytic role in the formation of ozone, as indeed they do in the formation of ozone in atmospheric reactions.

This paper is aimed at drawing the attention of designers of cryogenic systems in the LHC areas to the problem, in order that precautions can be taken at the design stage to reduce, or eliminate, the dangers of such explosions.

CONTENTS

1 Introduction

2 Historic

3 Explosions

4 Physical Properties of Cryogenic Fluids

4.1 General

4.2 Critical Explosive Concentrations.

5 Ozone formation

6 Cryostat Construction

7 Removal of ozone

8 Discussion

9 Acknowledgements

10 References

1 INTRODUCTION

Cryogenic fluids such as *Liquid Nitrogen , Argon and Helium* have been used for many years to provide low temperature environments for experimental and other purposes because they are inert, non flammable, non toxic and generally regarded as posing little hazard.

However under certain conditions explosions [1, 2, 3] have occurred, including some at CERN, notably in liquid nitrogen systems, after exposure to ionising radiation, for which, at the time, there was no explanation. Explosions have occurred in cryostats that have been subjected to doses of gamma radiation in the order of 10^4 Gy[4] , neutron fluxes of 10^{12} $n.cm^{-2}$ sec^{-1}. for a matter of two to three hours[5], and irradiation by a beam of 20 μA of 2.0 MeV electrons for 4 minutes[3].

Radiation levels in the proposed LHC experimental areas will be much higher than those reached in existing LEP areas with projected integrated doses in the order of 2,3 . 10^5 $Gy.yr^{-1}$, and neutron fluxes of 10^9 $n.cm^{-2}.sec^{-1}$ [6]. These values give cause for concern, particularly in the case of gamma radiation, as they are of the same magnitude as those reported in the literature where explosions have occurred.

The mechanisms of these explosions are very complex and are not yet fully understood. In this paper we review the existing literature on the subject and suggest precautions that may be required, or, further work that may be necessary to minimize explosion hazards in the LHC. Other explosions in liquefied gas containers have been caused by overpressure coupled with insufficient pressure relief, "roll-over" of the contents, or superheating resulting in the eventual catastrophic boiling of the contents. It is not intended in this paper to treat these phenomena as they are common to all cryogenic systems and are accounted for (or should be) in the design of all CERN systems.

2 HISTORIC

It might be supposed that chemical reactivity ceases at temperatures below about 100 K , but, on the contrary, many significant chemical syntheses have been described in which some operation requiring cryogenic temperatures forms a vital part of the procedure [7] .

The study of chemical reactivity at cryogenic temperatures is not new, the first experiments being reported at the end of the last century, when these fluids became available in sufficiently large quantities.

Large scale use of cryogenic fluids began in the early 1950's with the advent of the space and nuclear industries, their low cost and widespread availability has seen a multitude of uses in many fields.

3 EXPLOSIONS

As more research work was carried out, during the 1950's, into the effects of radiation on materials at cryogenic temperatures, explosions were reported for which there were no apparent explanations[3,5,8,9]. At first it was thought that the cryostat exhausts had become blocked by the formation of ice or as a result of design or operational errors, but it gradually became clear that some form of radiochemical reaction was taking place.

Liquid nitrogen was mainly used as the cooling media for these experiments, and therefore attention became focused on the possible contaminants. Commercial liquid nitrogen when delivered is usually relatively pure, however, it may easily become contaminated if it is allowed to come into contact with air. Due to their higher boiling points, oxygen and water vapour from the air are condensed and become dissolved in the liquid nitrogen.

It soon became clear that significant quantities of ozone (O_3) were being produced during the irradiation of material samples and that the ozone generation was due to the action of ionizing radiation on the relatively small quantities of dissolved oxygen present in the liquid nitrogen.

The generation of ozone during the operation of an experiment is of special interest not only because of the relatively high yields of ozone which are produced when oxygen is subjected to irradiation, but in particular due to the toxic and explosive properties of the gas.

As well as the production of ozone the irradiation of liquid nitrogen may also result in the formation of oxides of nitrogen (N_2O, NO, NO_2, N_2O_4 and N_2O_5) [10,11] and indeed the presence of a "sludge" of oxides of nitrogen has been reported at the bottom of liquid nitrogen cryostats after irradiation[4]. It is considered that the oxides of nitrogen are not the cause of the explosions but they seem to enhance the yield of ozone by a catalytic effect.

It has been suggested that "active" nitrogen, consisting of atoms and excited molecules of nitrogen, may be formed and be responsible for the explosions, but this is thought unlikely as it is so reactive that the molecules will not accumulate.

Violent explosions have occurred in experiments being conducted in cryostats of liquid nitrogen, and also in small, open glass vessels containing only milligram quantities of ozone. Sufficient explosive power is generated to shatter the internal components of cryostats or cryogenic containers. It appears that shock, local heating or even the presence of solid organic resins such as epoxies can trigger this type of explosion.

4 PHYSICAL PROPERTIES OF CRYOGENIC FLUIDS

4.1 General

The physical properties of the principal inert cryogenic fluids, together with those of oxygen, ozone and the principal oxides of nitrogen are given in Table 1.

FLUID	Boiling Pt. K (@1 atm.)	Melting Pt. K (@1 atm.)
Nitrogen (N_2)	77.35	63
Argon (Ar)	87.29	83.2
Helium (He)	4.22	-
Oxygen (O_2)	90.18	54.75
Ozone (O_3)	161.3	80.7
Nitrous Oxide (N_2O)	182.3	170.7
Nitric Oxide (NO)	122	112
Nitrogen Dioxide (NO_2/N_2O_4)	294.3	263.7
Nitrogen Pentoxide (N_2O_5)	320	303

Table 1: Boiling and melting points of liquefied gases

Since liquid oxygen is less volatile than either liquid nitrogen or argon, oxygen enrichment occurs as the liquid nitrogen boils off. If the cryostat is refilled before all the nitrogen has been allowed to boil off, then any condensed oxygen will remain. This is even more pronounced in the case of ozone. Therefore any ozone absorbed in either liquid nitrogen or argon will remain in solution as a dissolved solid.

Liquid oxygen and ozone have a pronounced blue colour and this colour has been reported by many workers in liquid nitrogen after irradiation.

At ambient temperature ozone is known to be unstable, it decomposes spontaneously if only relatively slowly. However the rate of decomposition is increased by the catalytic action of certain metals, the presence of other gases (e.g. NO), or by ionising radiation.

At temperatures below 90 K ozone is stable and does not decompose spontaneously, but under certain conditions it can decompose with explosive violence.

Explosions occur as ozone is rapidly reduced to oxygen (at a lower energy state) i.e. forming oxygen and releasing a large quantity of energy(12).

$$O_3 \rightarrow 3/2\ O_2$$

$$\Delta H = -3\ kJ.g^{-1}$$

This energy of explosion, or decomposition, is similar to the experimental value for the energy of explosion of TNT which has been measured as 4.686 $kJ.g^{-1}$ (13). Also the speed of detonation of pure ozone and TNT are very similar, at about 6000 $m.s^{-1}$.

4.2 Critical Explosive Concentrations

Chen et al.(5) postulate that the concentration of ozone needs to reach some critical value before explosions can take place. Cook et a1.(14) state that phase separation occurs giving a layer rich in ozone which enhances the probability of explosion.

Streng(15) found that this phase separation is dependent not only upon the concentration, but also upon the temperature of the mixture of O_2/O_3, N_2/O_3 or Ar/O_3. Experimental work carried out by the French "Commissariat a 1'energie atomique (CEA)" (16) confirms this earlier work, but explosions have been observed in Ar/O_3 mixtures at ozone concentrations below the values proposed by Streng.

	Temperature K	Theoretical min.O_3 concentration Mole % (Streng)	O_3 Concentration Mole % at which explosion occurred (CEA)
Oxygen	78.4	6.3	6.4
Nitrogen	77.0	4.4	5.8
Argon	85.0	8.3	4.9

Table 2: Ozone concentrations required to cause explosion

5 OZONE FORMATION

The amount of ozone formed in liquid nitrogen - oxygen mixtures exposed to ionising radiation was measured by Riley(17). and later by Gault(18). It was found that G(e), the number of ozone molecules formed per 100 eV, could be expressed as

$$G(e) = Goe + (8,05 + 1,29\log e)$$

This is valid for oxygen concentrations in the range 52 - 8,75. 10^4 ppm, where Go is the ozone yield, 12.5 molecules/100eV, from pure oxygen at 77 K, and shows that ozone production is relatively efficient even for low oxygen concentrations. For example, ozone formation in liquid nitrogen containing 10^4 ppm oxygen, 5.7 molecules/ 100eV, is only 2.2 times that found in nitrogen containing 52ppm oxygen, 2.6 molecules/ 100eV.

The formation of ozone in liquid argon is thought to be similar to that of liquid nitrogen , but to date little concrete work has been carried out to verify this.

Experiments by Sears J. T. et a1.[(19)], suggest that the formation of ozone is dependent on dose at low doses but independent of dose rate, however, the steady state concentration of ozone was dependent on dose rate. This is also suggested in a theoretical study carried out by Brereton12. Impurities also play a complex role and can radically affect the steady-state yield of ozone.

Table 3, gives the concentrations of ozone and oxides of nitrogen formed in various technical and liquefied gases on irradiation as found by Dmitriev [(20)]. The impurity concentrations (O_2?) of the inert gases was assumed to be 0.5%.

Irradiated medium	O_3 concentration at E =10^4 Gy. (mg.m^{-3})	NO_2 concentration at E =10^4 Gy . (mg .m^{-3})
Gaseous Oxygen	9.40 .10^2	9.7
Liquid Oxygen	2.7 .10^5	2.28 .10^3
Air	4.02 .10^2	2.90 .10^2
Liquid Air	1.5 .10^5	5 .10^4
Gaseous Nitrogen	45	11
Liquid Nitrogen	1.65 .10^3	1.17 .10^3
Argon	1.34 .10^2	1.05 .10^{-1}
Helium	8	1.3.10^{-2}

Table 3. Ozone formation in technical & liquefied gases

It is evident from table 3 that the ozone produced when liquefied gases are irradiated is of the order 100 times more than for the same gases at ambient temperatures and that oxides of nitrogen are formed, albeit in much smaller concentrations than ozone. Nevertheless oxides of nitrogen may play an important role in the reactions leading to the formation of ozone.

6. CRYOSTAT CONSTRUCTION

A number of reports in the literature suggest that the materials used in the construction of the cryostats play an important role in the formation of ozone and that this formation must be, at least in part, due to surface reactions.

Work carried out by Douglas J. E. et a1. [(21)] , show that the production of ozone can be dependent on the material in contact with the fluid in the cryostat.

Unsaturated organic compounds react with ozone to produce ozonides, which are subject to sudden decomposition[(22)], and as araldite and polystyrene, which both contain double bonds, are known to play important catalytic roles in the decomposition of ozone[(4)], this may be due to the formation of ozonides. Careful consideration should be given to their employment, and that of similar compounds, in cryostats.

Ozone may concentrate at the interface of the liquid surface and the vessel wall due to the preferential evaporation of the liquid nitrogen. It is important to chose materials with low wetting properties to limit this phenomena.

7. REMOVAL OF OZONE

Catalytic decomposition, or removal of ozone has been studied at ambient temperatures, but little work has been carried out into these processes at cryogenic temperatures.

Studies by d'Emel' Yanova et al [23,24] and Dewanckel et al.[25], into the catalytic decomposition of ozone in solution, in either liquid oxygen or nitrogen, indicate that platinum, palladium and to a lesser extent silver and copper are efficient at reducing ozone to oxygen. Certain metal oxides may also be employed to destroy ozone.

Activated carbon has a high adsorptive capacity for ozone even from dilute solutions, but this should not be considered as there is a risk of accumulating relatively large quantities of ozone, with the consequent risk of explosion when warming up the system.

8. DISCUSSION

It has been shown at CERN, and at other places, that explosions in cryogenic liquids can occur when these are exposed to ionising radiation. This radiation may be gamma rays, electrons or neutrons. The cryogenic liquid in which most explosions have taken place has been liquid nitrogen, with a few in liquid argon. The mechanism for the explosions is almost certainly the explosive decomposition of ozone, initiated by shock, or by the presence of polymeric materials in the construction of the cryostat or the presence of foreign matter such as dust particles acting as catalysts. The ozone is formed by the irradiation of oxygen impurities dissolved in the cryogenic liquid. There is some evidence that nitrogen plays a role in the reactions leading to the formation of ozone, but the preponderance of explosions in liquid nitrogen systems may simply be due to the fact that many more liquid nitrogen systems have been exposed to ionising radiation than have, for instance, liquid argon systems.

The quantity of ozone formed is a function of the total dose and very much less a function of the initial oxygen content. The effect of the dose rate is less clearly understood.

The above mechanism appears to represent a serious risk to the cryogenic systems being proposed for the LHC experiments, since quantities of cryogenic liquids will be found in zones of high radiation (e.g. EM Calorimeter end caps). The total annual dose will fall within the range known to create dangerous amounts of ozone in liquid nitrogen, or, argon and the complexity of the system could well facilitate the contamination of the cryogens by oxygen unless special precautions are taken.

It is of primary importance that these problems be addressed at the design stage, to reduce the potential danger by minimising the quantity of oxygen within the radiation field, for example using closed cycle secondary circuits filled with pure liquids cooled by heat exchange with commercial liquid nitrogen not exposed to ionising radiation.

It would be wise to monitor continuously the oxygen level in the cryogens exposed to ionising radiation and it may be necessary to design in systems for the removal of ozone as it is formed should the studies show that the risk to the cryogenic systems in the LHC experiments is such that it cannot be accepted.

This report has concentrated on the experimental areas where liquid nitrogen and argon will be present, for it is in these systems that most explosions have occurred. As far as we are aware there have been no reported incidents due to the problem of ozone formation and explosive decomposition in irradiated liquid helium. However there have been reports of ozone formation and explosion in solid air condensed on external cold sots of liquid helium cryogenic systems exposed to ionising radiation[(27)]. This problem should be taken into account in the design and operation of the cryogenic systems of the LHC machine.

As stated above, the total dose plays an important role in the formation of ozone, although the effects of dose rate and oxygen concentration are less clearly defined. The role played by nitrogen oxides in the formation of ozone is also unclear, as although these compounds do not appear to be the source of explosions, they may catalyse the formation of ozone. Further experimental work into the effects of dose rates and oxygen concentration would be of great value, as would work on the risks in liquid argon systems as much less information exists on this latter subject.

9. ACKNOWLEDGEMENTS

We are indebted to S. Brereton, of Lawrence Livermore Laboratory, L. C. Cadwallader of Idaho National Engineering Laboratory and G. Bon Mardion, of Commissariat a l'energie atomique, service des basses temperatures, for their contributions with respect to bibliographic references. These have enabled us to do a more complete search than we would other wise have been able to do. Also T. Ninikoski, L. Leistam and K. Potter for their help and encouragement.

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Lessard, Edward T

From: Meng, Wuzheng
Sent: Tuesday, December 30, 2003 4:00 PM
To: Lessard, Edward T; Makdisi, Yousef I; Pile, Philip H
Cc: Phillips, David B; Pendzick, Alexander F; Meng, Wuzheng
Subject: Status of Ozone Issue

Ozone_yield.doc (33 KB)   appendix.xls.xls (477 KB)

Ed, Yousef, and Phil,

After Dana alerted the ozone issue in MECO PS 80K shield on Dec 2002, I have studied many documents, and in March 03 I came up with a estimate of 9 gram O3 captured inside system after 1st year (1000 hr) run. (I assumed that O3 essentially does not boil away, because its boiling point 162K is much higher than N2 77K.)

During June 3 MECO safety audition, Brad Smith (MIT) gave a presentation "Ozone Buildup Issue". He used Bill Molzon's calculation to state that there will be 10 gram ozone boil away during 1000 hr. He also showed a sketch which suggests after the run, the liquid can be "flushed" out of the system.

On 12/12/03, during the MECO weekly telephone conference, Bill Molzon made two points: 1) ozone would be a problem because it exists in the LN2 as fine powders, and will be flushed out; 2) if GHe is used in shield, temperature gradient will be a problem, since this is a special solenoid (with target heating). I suggested Bill (or Brad) write up some articles to show the experimental safety committee. He seemed to agree.

Attached are two files which I have been working on since June. I have discussed with Ed several times. I used 1000 lines Excel spreadsheet to calculate the parameters: after 1000 hours, total ozone produced will be 9 gram; total ozone boil-off through the vents will be 2 gram; so that there will be 7 gram O3 remaining in the system (in copper pipes). This is about 21 KJ energy, if we use high purity LN2 (with 52 ppm O2 mole fraction). I also mentioned what went wrong in Brad(Bill)'s calculation, gently.

Ed suggests I publish it as our ES&F division tech note. I will appreciate if you make any comments, from the content to wordings.

Thanks for your time.

Wuzheng

Ozone Yield in PS 80 K Shield

W. Meng

(12/29/2003)

Background

On E940 (MECO) safety meeting (December 2002), Dana Beavis raised a question about possible explosion risks due to the activation of liquid nitrogen in the production solenoid (PS) 80 K shield. I was appointed by Ed Lessard to study this issue. I acquired many documents from Ed, Dana, and late on, from Don Crabb (University of Virginia).

Regardless the fact that the mechanisms of these explosions are very complex and are not yet fully understood, it is now widely accepted that these explosions are caused by the very rapid decomposition of ozone, which is formed by the action of ionizing radiation on oxygen dissolved in liquid nitrogen. The decomposition (from O3 to O2) generates 3 kJ for 1gram ozone at very rapid speed. Most explosions in the reactors happened during the warm up (for maintenance) while liquid nitrogen boiled off and the temperature was rising. Some explosions (in reactors and polarized beam targets) happened during the low temperature operations only if the ozone concentration achieved the critical point (4.4 mole %).

Ozone and oxygen do not disappear from the vents easily, simply because of their physical properties: oxygen's boiling point (90.18 K) is much higher than the nitrogen (77.35 K); ozone's melting point (80.7 K) and boiling point (161.3 K) are all higher than the liquid nitrogen temperature.

Calculations

In my early estimate, I just simply used ozone yield rate in Ref [1][2]: in high purity liquid nitrogen (52 ppm O2), 2.6 O3 molecules are produced under 100 eV radiation dose (mainly due to gamma and fast neutrons); I came up with 9 gram ozone in PS 80 K system after 1000 hour beam time.

In this note, I try to estimate the ozone yield under the considerations of possible ozone boil off and fresh liquid nitrogen flowing in. The detailed computations are in a separate Excel spreadsheet (filename: appendix.xls).

Reference 18 [1] in CERN note [2] was based on the accident analysis done by University of Missouri. The experiment setup mainly consists a cryostat (without refill), vent tubes and Drager gas-analysis apparatus which was used to determine the amount of ozone presented in the cryostat by measuring the ozone vapor concentration in the vent. The total net volume of the cryostat was 7.8 liter, and the boil off took 13 hours for a single cycle (without refill during the study). Initial impurity 0.005 (O_2 mole fraction) in the liquid nitrogen was assumed [1].

From the theory, the partial vapor pressure of ozone above the liquid nitrogen-ozone solution was calculated according to the following equation [1]:

$$P = Po * \exp[C*X(N2)] * X(O3) \qquad (1)$$

where C is a constant related to the mole volume of ozone and the solubility parameters of nitrogen and ozone; it was mentioned that the best number (by fitting) is C=7.0; X(N2) and X(O3) are the mole fractions of nitrogen and ozone in the liquid mixture, respectively; Po is the pure ozone vapor pressure at 77 K.

Part I of the Appendix lists the available pure ozone vapor pressure data from references [3], [4] and [5]. I choose the fitted crystalline ozone equation from [5]

$$\text{Log } P = 10.460 - 1021.6/T \qquad (2)$$

to get the pure ozone vapor pressure at liquid nitrogen temperature, since this is the only equation based on the measured data covers the low temperature range (from 66 K to 87 K).

In Part II of the Appendix, I computed the conversion factor from the ozone vapor relative pressure in the vent (in ppm), to the boil off rate (in gram/hour). The amount of ozone expelled from the vent is proportional to its vapor pressure except a constant. I then use this constant for evaluating Column P, in Part III of the Appendix.

In Part III of the Appendix, it calculated each parameter in the time interval of one hour, up to 1000 hours (assuming one fiscal year beam period):

Column B is the time, marked as the end of each hour.

Column C is the constant in equation (1) above;

Column D is the energy deposition in the unit of 100 eV per liter liquid per hour (18 μW/g was assumed as the radiation specific dose [6]);

Column E is the liquid (N_2 and O_2) volume in liter. It begins with 13.4 liter (MIT assumed 10.7 kg liquid nitrogen, with the density of 0.8 in the PS 80 K system); as time goes on, it reduces slightly, due to the production of ozone;

Column F is the oxygen mole fraction at the end of each hour. It begins with 52 ppm impurity, and also slightly reduces due to the production of ozone. The same impurity is assumed for the incoming fresh liquid portion;

Column G is the nitrogen mole fraction at the end of each hour, with the consideration of slight reduction due to accumulated ozone volume;

Column H is the electron fraction of the oxygen ε defined in Ref [1]; it begins with 59 ppm (equivalent to 52 ppm mole fraction);

Column I is the ozone forming rate at the end of each hour, in the unit of molecules per 100 eV energy deposition, as a function of ε, based on the equation (5) in Ref [1];

Column J is the ozone yield rate averaged over each hour, in the unit of molecules per hour, based on the modification of equation (10) in Ref [1]; and I have neglected its variation within one hour period;

Column K is the integrated ozone molecules from initial time t=0 to the end of each hour, after taking the boil off into account;

Column L is the ozone mole fraction at the end of each hour;

Column M is the pure ozone vapor pressure at liquid nitrogen temperature (77.35 K), in unit of mm mercury height (torr). The constant was interpolated by using equation (2) in this note (see the discussion above, and Ref [5]);

Column N is the ozone vapor pressure above the liquid, according to equation (4) in Ref [1] (or equation (1) in this note), in the unit of torr;

Column O is the ozone vapor pressure above the liquid normalized to one atmosphere pressure (760 mm Hg height), in the unit of ppm;

Column P is the ozone mass boil off rate averaged over each hour according to the early discussion in this note, in the unit of gram per hour.

As shown in summary cells, J1045, K1045 and P1045, after 1000 hours beam period, the total ozone produced will be around 9 gram, the total ozone boil off will be 2 gram, and the remaining ozone in the system will be around 7 gram.

Above calculation agrees with our previous simple estimate on the yield (in which the boil off ozone was ignored, and the incoming fresh liquid portion was also ignored). It basically agrees with the prediction from Univ. of Missouri's experiment: "…no appreciable amount of ozone is given off until the very end of the cycle, when the vapor pressure is such that concentrations are greater than 10 ppm in the vent gas. **This means that, if a system is refilled while appreciable liquid nitrogen remains, essentially all the ozone formed goes to the next cycle**"[1].

In Ref [7], author used pure ozone pressure data (Po=0.002 torr) from Ref [5] to estimate ozone boil off in MECO case, by applying on the ideal gas law directly; therefore, the ozone boil off (10 gram, after 1000 hours) was over estimated. If we use high purity liquid nitrogen in the PS system, the ozone will not reach the high concentration until near the end of the warm up; only towards that time, X(N2) approaches zero and X(O3) approaches to 1, as stated in equation (1) above, and the ozone vapor pressure P then approaches to the pure ozone vapor pressure Po. Ozone boil off rate actually is an indirect measure of its concentration in the liquid.

Issues

Above calculations show that the ozone concentration in the liquid is well below the critical level (see Appendix Column L), so that it is unlikely that explosion would occur during the operation (low temperature). The concern now is what could happen during the warm up for annual maintenance. Can 7gram ozone inside PS system cause potential risk during the warm up process? We need to address engineering studies. According to Ref [2], the energy (21 kJ, if high purity liquid nitrogen is used) will be released in a rapid speed (6000 m/s). We may argue that it would not damage the cryostat wall. Could it damage the 80 K shield, which is not designed for resisting much force? If the deformation causes the copper sheet to contact the coil cover or the cryostat wall, or locally compress the super-insulation layers too much, then the magnet will not be cooled down for the second year operation. Such "warm spot" problem has no simple solutions, and large equipment protection is part of our safety issues. Ref [7] also described an interesting idea of purging the 80 K system (copper pipes) before the warm up; the feasibility needs to be evaluated and developed, since this might have the impact on the engineering design of the magnet.

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Appendix of "Ozone Yield in PS 80 K Shield"

Part I -- Pure Ozone Vapor Pressure --- Po

Available Data	**Temperature Range**
Spangenbery: logPo = -6919.8/T + 1.75 logT -0.8239 T +146.56	**81 K to 90 K**
Jenkins/Birdsall: logPo = 8.25313 - 814.941587/T - 0.001966943 T **Gault et al: logPo = 8.25 -815/T - 0.002 T** (simplified from above)	**90 K to 216 K**
Hanson and Mauersberger: log Po = 10.460 - 1021.6/T	**66 K to 87 K**

Po = 0.0018 torr (to be used in Part III column M)
(T=77.35 K)

Part II -- Ozone Boil Off Rate -- (Which is Related to Ozone Vapor Pressure)

Quantity of Ozone Vapor (in pressure-volume units: mbar-lt) Expelled through Vent per ho

Since V(O3)=V(N2)=V(O2) -- assume all kinds vapor uniformly mixed at the vent exit --

PV = P(O3) * (0.64/4.604) * 3600
= P(O3)*5.00E2 (torr-lt)
= P(O3)*6.656E2 (mbar-lt)
P(O3) is Not Po!

LN2 Boil Off Rate = 127 (Watt)/199.3 (J/g) = 0.64 g/sec
density(N2) = 4.604 g/lt (at T=77.35 K)
1 torr = 1.333 mbar
P(O3) = ozone vapor pressure above the liquid (in torr)
(Part III column N below)

O3 Boil Off Mass (in gram/hour) --

M(O3) = PV * m/(RT) = P(O3) *6.656E2 * 48 /83.14/300
= P(O3) * 4.97 (gram/hour)
(to be used in Part III column P)

M(O3) = ozone boil off mass/hour
V (Volume) = 6.66E+02 liter (per hour)
m (O3 mass/mol)= 48 gram/mole
R (const) = 83.14 mbar-lt/mol/K
T (temp) = 77.35 K

Part III -- Computation of Ozone Production, Boil Off, and Accumulation in MECO PS 80 K System

symbol	t	C	A	Vo	X(O2)	X(N2)	e (epsilon)	G(e)	n(O3)	N(O3)	X(O3)	Po	P(O3)	P(O3)/P(atm)	M(O3)
name	Time	Constant	Energy Depositio	Liquid Volume	O2 mole fraction	N2 mole fraction	O2 electron fraction	O3 form rate	O3 yield rate	integrated O3	O3 mole fraction	pure O3 pressure	O3 pressure	ratio to standard	O3 boil-off rate
unit	(hour)		(100eV/lt/hr)	(liter)				(molecules/100eV)	(molecules/hr)	(molecules)	at time=t	at 77 K (torr)	above liquid (torr)	(ppm)	(gram/hour)
	0	7	3.23482E+18	13.4	0.000052	0.999948	5.94286E-05	2.599196782	0	0	0	0.0018	0	0	0
	1	7	3.23482E+18	13.4	0.000052	0.999948	5.94286E-05	2.599196782	1.12666E+20	1.12666E+20	4.88589E-07	0.0018	9.64095E-07	0.001268546	4.79155E-06
	2	7	3.23482E+18	13.39999472	5.2E-05	0.999947511	5.94285E-05	2.599196508	1.12666E+20	2.25272E+20	9.76918E-07	0.0018	1.92767E-06	0.002536406	9.58051E-06
	3	7	3.23482E+18	13.39998944	5.19999E-05	0.999947023	5.94285E-05	2.599196234	1.12666E+20	3.37818E+20	1.46499E-06	0.0018	2.89072E-06	0.003803582	1.43669E-05
	4	7	3.23482E+18	13.39998416	5.19999E-05	0.999946535	5.94285E-05	2.59919596	1.12666E+20	4.50304E+20	1.95279E-06	0.0018	3.85326E-06	0.005070073	1.91507E-05
	5	7	3.23482E+18	13.39997889	5.19999E-05	0.999946047	5.94285E-05	2.599195687	1.12666E+20	5.62729E+20	2.44034E-06	0.0018	4.81527E-06	0.00633588	2.39319E-05
	6	7	3.23482E+18	13.39997362	5.19999E-05	0.99994556	5.94284E-05	2.599195413	1.12666E+20	6.75095E+20	2.92763E-06	0.0018	5.77676E-06	0.007601003	2.87105E-05
	7	7	3.23482E+18	13.39996835	5.19998E-05	0.999945073	5.94284E-05	2.59919514	1.12666E+20	7.87401E+20	3.41466E-06	0.0018	6.73774E-06	0.008865443	3.34866E-05
	8	7	3.23482E+18	13.39996309	5.19998E-05	0.999944586	5.94284E-05	2.599194866	1.12666E+20	8.99646E+20	3.90143E-06	0.0018	7.69819E-06	0.0101292	3.826E-05
	9	7	3.23482E+18	13.39995783	5.19998E-05	0.999944099	5.94283E-05	2.599194593	1.12666E+20	1.01183E+21	4.38793E-06	0.0018	8.65813E-06	0.011392274	4.30309E-05
	10	7	3.23482E+18	13.39995257	5.19998E-05	0.999943612	5.94283E-05	2.59919432	1.12666E+20	1.12396E+21	4.87418E-06	0.0018	9.61755E-06	0.012654666	4.77992E-05
	11	7	3.23482E+18	13.39994731	5.19997E-05	0.999943126	5.94283E-05	2.599194048	1.12666E+20	1.23602E+21	5.36017E-06	0.0018	1.05764E-05	0.013916376	5.25649E-05
	12	7	3.23482E+18	13.39994206	5.19997E-05	0.99994264	5.94283E-05	2.599193775	1.12666E+20	1.34803E+21	5.8459E-06	0.0018	1.15348E-05	0.015177404	5.73281E-05
	13	7	3.23482E+18	13.39993681	5.19997E-05	0.999942154	5.94282E-05	2.599193503	1.12665E+20	1.45998E+21	6.33137E-06	0.0018	1.24927E-05	0.016437752	6.20887E-05
	14	7	3.23482E+18	13.39993156	5.19997E-05	0.999941669	5.94282E-05	2.59919323	1.12665E+20	1.57186E+21	6.81659E-06	0.0018	1.345E-05	0.017697419	6.68467E-05
	15	7	3.23482E+18	13.39992631	5.19996E-05	0.999941184	5.94282E-05	2.599192958	1.12665E+20	1.68369E+21	7.30154E-06	0.0018	1.44069E-05	0.018956405	7.16021E-05
	16	7	3.23482E+18	13.39992107	5.19996E-05	0.999940699	5.94281E-05	2.599192686	1.12665E+20	1.79546E+21	7.78624E-06	0.0018	1.53632E-05	0.020214711	7.6355E-05
	17	7	3.23482E+18	13.39991583	5.19996E-05	0.999940214	5.94281E-05	2.599192414	1.12665E+20	1.90716E+21	8.27067E-06	0.0018	1.6319E-05	0.021472338	8.11053E-05
	18	7	3.23482E+18	13.39991059	5.19996E-05	0.99993973	5.94281E-05	2.599192142	1.12665E+20	2.01881E+21	8.75485E-06	0.0018	1.72743E-05	0.022729286	8.58531E-05
	19	7	3.23482E+18	13.39990536	5.19995E-05	0.999939246	5.94281E-05	2.599191871	1.12665E+20	2.1304E+21	9.23877E-06	0.0018	1.8229E-05	0.023985554	9.05982E-05
	20	7	3.23482E+18	13.39990013	5.19995E-05	0.999938762	5.9428E-05	2.599191599	1.12665E+20	2.24193E+21	9.72243E-06	0.0018	1.91833E-05	0.025241145	9.53409E-05
	21	7	3.23482E+18	13.3998949	5.19995E-05	0.999938278	5.9428E-05	2.599191328	1.12665E+20	2.35339E+21	1.02058E-05	0.0018	2.0137E-05	0.026496057	0.000100081
	22	7	3.23482E+18	13.39988967	5.19995E-05	0.999937795	5.9428E-05	2.599191057	1.12665E+20	2.4648E+21	1.0689E-05	0.0018	2.10902E-05	0.027750291	0.000104818
	23	7	3.23482E+18	13.39988445	5.19994E-05	0.999937312	5.94279E-05	2.599190786	1.12665E+20	2.57615E+21	1.11719E-05	0.0018	2.20429E-05	0.029003848	0.000109553
	24	7	3.23482E+18	13.39987923	5.19994E-05	0.999936829	5.94279E-05	2.599190515	1.12665E+20	2.68744E+21	1.16545E-05	0.0018	2.29951E-05	0.030256728	0.000114286
	25	7	3.23482E+18	13.39987401	5.19994E-05	0.999936346	5.94279E-05	2.599190244	1.12665E+20	2.79867E+21	1.21369E-05	0.0018	2.39468E-05	0.031508931	0.000119016
	26	7	3.23482E+18	13.3998688	5.19994E-05	0.999935864	5.94279E-05	2.599189973	1.12665E+20	2.90985E+21	1.2619E-05	0.0018	2.48979E-05	0.032760459	0.000123743
	27	7	3.23482E+18	13.39986359	5.19993E-05	0.999935382	5.94278E-05	2.599189703	1.12665E+20	3.02096E+21	1.31009E-05	0.0018	2.58486E-05	0.03401131	0.000128468
	28	7	3.23482E+18	13.39985838	5.19993E-05	0.9999349	5.94278E-05	2.599189433	1.12665E+20	3.13201E+21	1.35825E-05	0.0018	2.67987E-05	0.035261486	0.00013319
	29	7	3.23482E+18	13.39985317	5.19993E-05	0.999934418	5.94278E-05	2.599189162	1.12665E+20	3.243E+21	1.40638E-05	0.0018	2.77483E-05	0.036510986	0.000137909
	30	7	3.23482E+18	13.39984797	5.19993E-05	0.999933937	5.94277E-05	2.599188892	1.12665E+20	3.35394E+21	1.45449E-05	0.0018	2.86975E-05	0.037759812	0.000142626
	31	7	3.23482E+18	13.39984277	5.19992E-05	0.999933456	5.94277E-05	2.599188623	1.12664E+20	3.46481E+21	1.50257E-05	0.0018	2.96461E-05	0.039007964	0.000147341
	32	7	3.23482E+18	13.39983757	5.19992E-05	0.999932975	5.94277E-05	2.599188353	1.12664E+20	3.57563E+21	1.55063E-05	0.0018	3.05941E-05	0.040255441	0.000152053
	33	7	3.23482E+18	13.39983238	5.19992E-05	0.999932495	5.94276E-05	2.599188083	1.12664E+20	3.68639E+21	1.59866E-05	0.0018	3.15417E-05	0.041502245	0.000156762
	34	7	3.23482E+18	13.39982719	5.19992E-05	0.999932014	5.94276E-05	2.599187814	1.12664E+20	3.79708E+21	1.64667E-05	0.0018	3.24888E-05	0.042748376	0.000161469
	35	7	3.23482E+18	13.399822	5.19991E-05	0.999931534	5.94276E-05	2.599187544	1.12664E+20	3.90772E+21	1.69465E-05	0.0018	3.34353E-05	0.043993833	0.000166174
	36	7	3.23482E+18	13.39981681	5.19991E-05	0.999931054	5.94276E-05	2.599187275	1.12664E+20	4.0183E+21	1.7426E-05	0.0018	3.43813E-05	0.045238618	0.000170875
	37	7	3.23482E+18	13.39981163	5.19991E-05	0.999930575	5.94275E-05	2.599187006	1.12664E+20	4.12882E+21	1.79053E-05	0.0018	3.53269E-05	0.046482731	0.000175575
	38	7	3.23482E+18	13.39980644	5.19991E-05	0.999930096	5.94275E-05	2.599186737	1.12664E+20	4.23928E+21	1.83844E-05	0.0018	3.62719E-05	0.047726173	0.000180271
	39	7	3.23482E+18	13.39980127	5.1999E-05	0.999929617	5.94275E-05	2.599186469	1.12664E+20	4.34968E+21	1.88632E-05	0.0018	3.72164E-05	0.048968943	0.000184965
	40	7	3.23482E+18	13.39979609	5.1999E-05	0.999929138	5.94275E-05	2.5991862	1.12664E+20	4.46003E+21	1.93417E-05	0.0018	3.81604E-05	0.050211041	0.000189657
	41	7	3.23482E+18	13.39979092	5.1999E-05	0.999928659	5.94274E-05	2.599185932	1.12664E+20	4.57031E+21	1.982E-05	0.0018	3.91039E-05	0.051452469	0.000194346
	42	7	3.23482E+18	13.39978575	5.1999E-05	0.999928181	5.94274E-05	2.599185663	1.12664E+20	4.68054E+21	2.0298E-05	0.0018	4.00469E-05	0.052693227	0.000199033
	43	7	3.23482E+18	13.39978058	5.19989E-05	0.999927703	5.94274E-05	2.599185395	1.12664E+20	4.7907E+21	2.07757E-05	0.0018	4.09893E-05	0.053933315	0.000203717
	44	7	3.23482E+18	13.39977542	5.19989E-05	0.999927225	5.94273E-05	2.599185127	1.12664E+20	4.90081E+21	2.12533E-05	0.0018	4.19313E-05	0.055172734	0.000208398
	45	7	3.23482E+18	13.39977025	5.19989E-05	0.999926748	5.94273E-05	2.599184859	1.12664E+20	5.01086E+21	2.17305E-05	0.0018	4.28727E-05	0.056411483	0.000213077
	46	7	3.23482E+18	13.3997651	5.19989E-05	0.999926271	5.94273E-05	2.599184591	1.12664E+20	5.12085E+21	2.22075E-05	0.0018	4.38137E-05	0.057649563	0.000217754
	47	7	3.23482E+18	13.39975994	5.19988E-05	0.999925794	5.94273E-05	2.599184324	1.12664E+20	5.23078E+21	2.26843E-05	0.0018	4.47541E-05	0.058886975	0.000222428
	48	7	3.23482E+18	13.39975479	5.19988E-05	0.999925317	5.94272E-05	2.599184056	1.12664E+20	5.34065E+21	2.31607E-05	0.0018	4.5694E-05	0.060123719	0.000227099
	49	7	3.23482E+18	13.39974963	5.19988E-05	0.99992484	5.94272E-05	2.599183789	1.12664E+20	5.45047E+21	2.3637E-05	0.0018	4.66334E-05	0.061359795	0.000231768
	50	7	3.23482E+18	13.39974449	5.19988E-05	0.999924364	5.94272E-05	2.599183522	1.12663E+20	5.56022E+21	2.4113E-05	0.0018	4.75724E-05	0.062595204	0.000236435
	51	7	3.23482E+18	13.39973934	5.19987E-05	0.999923888	5.94271E-05	2.599183255	1.12663E+20	5.66992E+21	2.45887E-05	0.0018	4.85108E-05	0.063829945	0.000241098
	52	7	3.23482E+18	13.3997342	5.19987E-05	0.999923413	5.94271E-05	2.599182988	1.12663E+20	5.77956E+21	2.50642E-05	0.0018	4.94487E-05	0.06506402	0.00024576
	53	7	3.23482E+18	13.39972906	5.19987E-05	0.999922937	5.94271E-05	2.599182721	1.12663E+20	5.88914E+21	2.55394E-05	0.0018	5.0386E-05	0.066297429	0.000250419
	54	7	3.23482E+18	13.39972392	5.19987E-05	0.999922462	5.94271E-05	2.599182455	1.12663E+20	5.99866E+21	2.60144E-05	0.0018	5.13229E-05	0.067530172	0.000255075
	55	7	3.23482E+18	13.39971879	5.19986E-05	0.999921987	5.9427E-05	2.599182188	1.12663E+20	6.10812E+21	2.64891E-05	0.0018	5.22593E-05	0.06876225	0.000259729
	56	7	3.23482E+18	13.39971366	5.19986E-05	0.999921512	5.9427E-05	2.599181922	1.12663E+20	6.21752E+21	2.69635E-05	0.0018	5.31952E-05	0.069993662	0.00026438
	57	7	3.23482E+18	13.39970853	5.19986E-05	0.999921038	5.9427E-05	2.599181656	1.12663E+20	6.32687E+21	2.74378E-05	0.0018	5.41306E-05	0.07122441	0.000269029
	58	7	3.23482E+18	13.3997034	5.19986E-05	0.999920564	5.94269E-05	2.59918139	1.12663E+20	6.43616E+21	2.79117E-05	0.0018	5.50654E-05	0.072454493	0.000273675
	59	7	3.23482E+18	13.39969828	5.19985E-05	0.99992009	5.94269E-05	2.599181124	1.12663E+20	6.54538E+21	2.83854E-05	0.0018	5.59998E-05	0.073683912	0.000278319
	60	7	3.23482E+18	13.39969316	5.19985E-05	0.999919616	5.94269E-05	2.599180858	1.12663E+20	6.65456E+21	2.88589E-05	0.0018	5.69336E-05	0.074912668	0.00028296
	61	7	3.23482E+18	13.39968804	5.19985E-05	0.999919143	5.94269E-05	2.599180592	1.12663E+20	6.76367E+21	2.93321E-05	0.0018	5.7867E-05	0.07614076	0.000287599
	62	7	3.23482E+18	13.39968293	5.19985E-05	0.999918669	5.94268E-05	2.599180327	1.12663E+20	6.87272E+21	2.9805E-05	0.0018	5.87998E-05	0.077368189	0.000292235
	63	7	3.23482E+18	13.39967781	5.19985E-05	0.999918197	5.94268E-05	2.599180062	1.12663E+20	6.98172E+21	3.02777E-05	0.0018	5.97322E-05	0.078594956	0.000296869
	64	7	3.23482E+18	13.3996727	5.19984E-05	0.999917724	5.94268E-05	2.599179797	1.12663E+20	7.09065E+21	3.07502E-05	0.0018	6.0664E-05	0.07982106	0.0003015
	65	7	3.23482E+18	13.3996676	5.19984E-05	0.999917251	5.94267E-05	2.599179531	1.12663E+20	7.19953E+21	3.12223E-05	0.0018	6.15953E-05	0.081046503	0.000306129
	66	7	3.23482E+18	13.39966249	5.19984E-05	0.999916779	5.94267E-05	2.599179267	1.12663E+20	7.30836E+21	3.16943E-05	0.0018	6.25262E-05	0.082271284	0.000310755
	67	7	3.23482E+18	13.39965739	5.19984E-05	0.999916307	5.94267E-05	2.599179002	1.12663E+20	7.41712E+21	3.2166E-05	0.0018	6.34565E-05	0.083495404	0.000315379
	68	7	3.23482E+18	13.39965229	5.19983E-05	0.999915836	5.94267E-05	2.599178737	1.12662E+20	7.52582E+21	3.26374E-05	0.0018	6.43863E-05	0.084718863	0.00032
	69	7	3.23482E+18	13.3996472	5.19983E-05	0.999915364	5.94266E-05	2.599178473	1.12662E+20	7.63447E+21	3.31086E-05	0.0018	6.53157E-05	0.085941662	0.000324619
	70	7	3.23482E+18	13.3996421	5.19983E-05	0.999914893	5.94266E-05	2.599178208	1.12662E+20	7.74306E+21	3.35795E-05	0.0018	6.62445E-05	0.087163801	0.000329235
	71	7	3.23482E+18	13.39963701	5.19983E-05	0.999914422	5.94266E-05	2.599177944	1.12662E+20	7.85159E+21	3.40502E-05	0.0018	6.71728E-05	0.08838528	0.000333849
	72	7	3.23482E+18	13.39963192	5.19982E-05	0.999913952	5.94265E-05	2.59917768	1.12662E+20	7.96006E+21	3.45206E-05	0.0018	6.81006E-05	0.0896061	0.00033846
	73	7	3.23482E+18	13.39962684	5.19982E-05	0.999913481	5.94265E-05	2.599177416	1.12662E+20	8.06848E+21	3.49908E-05	0.0018	6.9028E-05	0.090826261	0.000343069
	74	7	3.23482E+18	13.39962176	5.19982E-05	0.999913011	5.94265E-05	2.599177152	1.12662E+20	8.17684E+21	3.54608E-05	0.0018	6.99548E-05	0.092045763	0.000347675
	75	7	3.23482E+18	13.39961668	5.19982E-05	0.999912541	5.94265E-05	2.599176889	1.12662E+20	8.28514E+21	3.59304E-05	0.0018	7.08811E-05	0.093264607	0.000352279
	76	7	3.23482E+18	13.3996116	5.19981E-05	0.999912071	5.94264E-05	2.599176625	1.12662E+20	8.39338E+21	3.63999E-05	0.0018	7.18069E-05	0.094482794	0.00035688
	77	7	3.23482E+18	13.39960653	5.19981E-05	0.999911602	5.94264E-05	2.599176362	1.12662E+20	8.50156E+21	3.6869E-05	0.0018	7.27322E-05	0.095700322	0.000361479
	78	7	3.23482E+18	13.39960145	5.19981E-05	0.999911133	5.94264E-05	2.599176099	1.12662E+20	8.60969E+21	3.7338E-05	0.0018	7.36571E-05	0.096917194	0.000366076
	79	7	3.23482E+18	13.39959639	5.19981E-05	0.999910664	5.94264E-05	2.599175836	1.12662E+20	8.71776E+21	3.78066E-05	0.0018	7.45814E-05	0.098133409	0.00037067
	80	7	3.23482E+18	13.39959132	5.1998E-05	0.999910195	5.94263E-05	2.599175573	1.12662E+20	8.82577E+21	3.82751E-05	0.0018	7.55052E-05	0.099348968	0.000375261
	81	7	3.23482E+18	13.39958626	5.1998E-05	0.999909727	5.94263E-05	2.59917531	1.12662E+20	8.93372E+21	3.87433E-05	0.0018	7.64285E-05	0.10056387	0.00037985
	82	7	3.23482E+18	13.3995812	5.1998E-05	0.999909259	5.94263E-05	2.599175047	1.12662E+20	9.04162E+21	3.92112E-05	0.0018	7.73514E-05	0.101778117	0.000384436
	83	7	3.23482E+18	13.39957614	5.1998E-05	0.999908791	5.94262E-05	2.599174785	1.12662E+20	9.14945E+21	3.96789E-05	0.0018	7.82737E-05	0.102991708	0.00038902
	84	7	3.23482E+18	13.39957108	5.19979E-05	0.999908323	5.94262E-05	2.599174522	1.12662E+20	9.25723E+21	4.01463E-05	0.0018	7.91955E-05	0.104204645	0.000393602
	85	7	3.23482E+18	13.39956603	5.19979E-05	0.999907856	5.94262E-05	2.59917426	1.12662E+20	9.36496E+21	4.06135E-05	0.0018	8.01169E-05	0.105416927	0.000398181
	86	7	3.23482E+18	13.39956098	5.19979E-05	0.999907389	5.94262E-05	2.599173998	1.12661E+20	9.47262E+21	4.10804E-05	0.0018	8.10377E-05	0.106628555	0.000402757

87	7	3.23482E+18	13.39955593	5.19979E-05	0.999906922	5.94261E-05	2.599173736	1.12661E+20	9.58023E+21	4.15471E-05	0.0018	8.1958E-05	0.107839529	0.000407331
88	7	3.23482E+18	13.39955089	5.19978E-05	0.999906455	5.94261E-05	2.599173474	1.12661E+20	9.68778E+21	4.20135E-05	0.0018	8.28779E-05	0.109049849	0.000411903
89	7	3.23482E+18	13.39954585	5.19978E-05	0.999905989	5.94261E-05	2.599173213	1.12661E+20	9.79527E+21	4.24797E-05	0.0018	8.37972E-05	0.110259516	0.000416472
90	7	3.23482E+18	13.39954081	5.19978E-05	0.999905522	5.9426E-05	2.599172951	1.12661E+20	9.90271E+21	4.29457E-05	0.0018	8.47161E-05	0.111468531	0.000421039
91	7	3.23482E+18	13.39953577	5.19978E-05	0.999905057	5.9426E-05	2.59917269	1.12661E+20	1.00101E+22	4.34113E-05	0.0018	8.56344E-05	0.112676893	0.000425603
92	7	3.23482E+18	13.39953074	5.19977E-05	0.999904591	5.9426E-05	2.599172428	1.12661E+20	1.01174E+22	4.38768E-05	0.0018	8.65523E-05	0.113884603	0.000430165
93	7	3.23482E+18	13.3995257	5.19977E-05	0.999904125	5.9426E-05	2.599172167	1.12661E+20	1.02247E+22	4.4342E-05	0.0018	8.74697E-05	0.115091661	0.000434724
94	7	3.23482E+18	13.39952068	5.19977E-05	0.99990366	5.94259E-05	2.599171906	1.12661E+20	1.03319E+22	4.48069E-05	0.0018	8.83865E-05	0.116298068	0.000439281
95	7	3.23482E+18	13.39951565	5.19977E-05	0.999903195	5.94259E-05	2.599171646	1.12661E+20	1.0439E+22	4.52716E-05	0.0018	8.93029E-05	0.117503824	0.000443835
96	7	3.23482E+18	13.39951063	5.19976E-05	0.999902731	5.94259E-05	2.599171385	1.12661E+20	1.05461E+22	4.57361E-05	0.0018	9.02188E-05	0.118708929	0.000448387
97	7	3.23482E+18	13.39950561	5.19976E-05	0.999902266	5.94259E-05	2.599171124	1.12661E+20	1.06532E+22	4.62003E-05	0.0018	9.11342E-05	0.119913384	0.000452937
98	7	3.23482E+18	13.39950059	5.19976E-05	0.999901802	5.94258E-05	2.599170864	1.12661E+20	1.07601E+22	4.66642E-05	0.0018	9.20491E-05	0.121117189	0.000457484
99	7	3.23482E+18	13.39949557	5.19976E-05	0.999901338	5.94258E-05	2.599170604	1.12661E+20	1.0867E+22	4.71279E-05	0.0018	9.29635E-05	0.122320344	0.000462028
100	7	3.23482E+18	13.39949056	5.19975E-05	0.999900875	5.94258E-05	2.599170343	1.12661E+20	1.09739E+22	4.75914E-05	0.0018	9.38774E-05	0.123522851	0.000466571
101	7	3.23482E+18	13.39948555	5.19975E-05	0.999900411	5.94257E-05	2.599170083	1.12661E+20	1.10807E+22	4.80546E-05	0.0018	9.47908E-05	0.124724708	0.00047111
102	7	3.23482E+18	13.39948055	5.19975E-05	0.999899948	5.94257E-05	2.599169824	1.12661E+20	1.11875E+22	4.85176E-05	0.0018	9.57037E-05	0.125925917	0.000475647
103	7	3.23482E+18	13.39947554	5.19975E-05	0.999899485	5.94257E-05	2.599169564	1.12661E+20	1.12942E+22	4.89803E-05	0.0018	9.66161E-05	0.127126478	0.000480182
104	7	3.23482E+18	13.39947054	5.19975E-05	0.999899022	5.94257E-05	2.599169304	1.12661E+20	1.14008E+22	4.94428E-05	0.0018	9.75281E-05	0.128326391	0.000484714
105	7	3.23482E+18	13.39946554	5.19974E-05	0.99989856	5.94256E-05	2.599169045	1.1266E+20	1.15074E+22	4.9905E-05	0.0018	9.84395E-05	0.129525657	0.000489244
106	7	3.23482E+18	13.39946054	5.19974E-05	0.999898098	5.94256E-05	2.599168786	1.1266E+20	1.16139E+22	5.0367E-05	0.0018	9.93504E-05	0.130724275	0.000493772
107	7	3.23482E+18	13.39945555	5.19974E-05	0.999897636	5.94256E-05	2.599168526	1.1266E+20	1.17204E+22	5.08287E-05	0.0018	0.000100261	0.131922247	0.000498297
108	7	3.23482E+18	13.39945056	5.19974E-05	0.999897174	5.94256E-05	2.599168267	1.1266E+20	1.18268E+22	5.12902E-05	0.0018	0.000101171	0.133119573	0.000502819
109	7	3.23482E+18	13.39944557	5.19973E-05	0.999896712	5.94255E-05	2.599168008	1.1266E+20	1.19331E+22	5.17514E-05	0.0018	0.00010208	0.134316252	0.000507339
110	7	3.23482E+18	13.39944059	5.19973E-05	0.999896251	5.94255E-05	2.59916775	1.1266E+20	1.20394E+22	5.22124E-05	0.0018	0.000102989	0.135512286	0.000511857
111	7	3.23482E+18	13.3994356	5.19973E-05	0.99989579	5.94255E-05	2.599167491	1.1266E+20	1.21456E+22	5.26732E-05	0.0018	0.000103898	0.136707675	0.000516372
112	7	3.23482E+18	13.39943062	5.19973E-05	0.99989533	5.94254E-05	2.599167233	1.1266E+20	1.22518E+22	5.31337E-05	0.0018	0.000104806	0.137902419	0.000520885
113	7	3.23482E+18	13.39942564	5.19972E-05	0.999894869	5.94254E-05	2.599166974	1.1266E+20	1.2358E+22	5.35939E-05	0.0018	0.000105713	0.139096518	0.000525395
114	7	3.23482E+18	13.39942067	5.19972E-05	0.999894409	5.94254E-05	2.599166716	1.1266E+20	1.2464E+22	5.40539E-05	0.0018	0.00010662	0.140289973	0.000529903
115	7	3.23482E+18	13.3994157	5.19972E-05	0.999893949	5.94254E-05	2.599166458	1.1266E+20	1.257E+22	5.45137E-05	0.0018	0.000107527	0.141482784	0.000534409
116	7	3.23482E+18	13.39941073	5.19972E-05	0.999893489	5.94253E-05	2.5991662	1.1266E+20	1.2676E+22	5.49732E-05	0.0018	0.000108433	0.142674952	0.000538912
117	7	3.23482E+18	13.39940576	5.19971E-05	0.99989303	5.94253E-05	2.599165942	1.1266E+20	1.27819E+22	5.54325E-05	0.0018	0.000109339	0.143866476	0.000543412
118	7	3.23482E+18	13.3994008	5.19971E-05	0.99989257	5.94253E-05	2.599165684	1.1266E+20	1.28877E+22	5.58915E-05	0.0018	0.000110244	0.145057358	0.000547911
119	7	3.23482E+18	13.39939583	5.19971E-05	0.999892111	5.94252E-05	2.599165427	1.1266E+20	1.29935E+22	5.63503E-05	0.0018	0.000111148	0.146247597	0.000552406
120	7	3.23482E+18	13.39939088	5.19971E-05	0.999891653	5.94252E-05	2.59916517	1.1266E+20	1.30992E+22	5.68089E-05	0.0018	0.000112052	0.147437194	0.0005569
121	7	3.23482E+18	13.39938592	5.1997E-05	0.999891194	5.94252E-05	2.599164912	1.1266E+20	1.32049E+22	5.72672E-05	0.0018	0.000112956	0.14862615	0.000561391
122	7	3.23482E+18	13.39938097	5.1997E-05	0.999890736	5.94252E-05	2.599164655	1.1266E+20	1.33105E+22	5.77252E-05	0.0018	0.000113859	0.149814464	0.000565879
123	7	3.23482E+18	13.39937601	5.1997E-05	0.999890278	5.94251E-05	2.599164398	1.1266E+20	1.34161E+22	5.8183E-05	0.0018	0.000114762	0.151002137	0.000570365
124	7	3.23482E+18	13.39937107	5.1997E-05	0.99988982	5.94251E-05	2.599164141	1.12659E+20	1.35216E+22	5.86406E-05	0.0018	0.000115664	0.152189169	0.000574849
125	7	3.23482E+18	13.39936612	5.1997E-05	0.999889362	5.94251E-05	2.599163885	1.12659E+20	1.3627E+22	5.90979E-05	0.0018	0.000116565	0.153375561	0.00057933
126	7	3.23482E+18	13.39936118	5.19969E-05	0.999888905	5.94251E-05	2.599163628	1.12659E+20	1.37324E+22	5.9555E-05	0.0018	0.000117467	0.154561313	0.000583809
127	7	3.23482E+18	13.39935624	5.19969E-05	0.999888448	5.9425E-05	2.599163372	1.12659E+20	1.38378E+22	6.00118E-05	0.0018	0.000118367	0.155746425	0.000588285
128	7	3.23482E+18	13.3993513	5.19969E-05	0.999887991	5.9425E-05	2.599163115	1.12659E+20	1.3943E+22	6.04684E-05	0.0018	0.000119267	0.156930899	0.000592759
129	7	3.23482E+18	13.39934636	5.19969E-05	0.999887535	5.9425E-05	2.599162859	1.12659E+20	1.40483E+22	6.09248E-05	0.0018	0.000120167	0.158114733	0.000597231
130	7	3.23482E+18	13.39934143	5.19968E-05	0.999887078	5.9425E-05	2.599162603	1.12659E+20	1.41534E+22	6.13809E-05	0.0018	0.000121066	0.159297929	0.0006017
131	7	3.23482E+18	13.3993365	5.19968E-05	0.999886622	5.94249E-05	2.599162347	1.12659E+20	1.42585E+22	6.18367E-05	0.0018	0.000121965	0.160480486	0.000606167
132	7	3.23482E+18	13.39933157	5.19968E-05	0.999886166	5.94249E-05	2.599162092	1.12659E+20	1.43636E+22	6.22924E-05	0.0018	0.000122863	0.161662406	0.000610631
133	7	3.23482E+18	13.39932665	5.19968E-05	0.999885711	5.94249E-05	2.599161836	1.12659E+20	1.44686E+22	6.27477E-05	0.0018	0.000123761	0.162843688	0.000615093
134	7	3.23482E+18	13.39932173	5.19967E-05	0.999885256	5.94248E-05	2.599161581	1.12659E+20	1.45735E+22	6.32029E-05	0.0018	0.000124658	0.164024333	0.000619553
135	7	3.23482E+18	13.39931681	5.19967E-05	0.9998848	5.94248E-05	2.599161325	1.12659E+20	1.46784E+22	6.36578E-05	0.0018	0.000125555	0.165204341	0.00062401
136	7	3.23482E+18	13.39931189	5.19967E-05	0.999884346	5.94248E-05	2.59916107	1.12659E+20	1.47832E+22	6.41124E-05	0.0018	0.000126452	0.166383713	0.000628465
137	7	3.23482E+18	13.39930698	5.19967E-05	0.999883891	5.94248E-05	2.599160815	1.12659E+20	1.4888E+22	6.45668E-05	0.0018	0.000127347	0.167562448	0.000632917
138	7	3.23482E+18	13.39930206	5.19966E-05	0.999883437	5.94247E-05	2.59916056	1.12659E+20	1.49927E+22	6.5021E-05	0.0018	0.000128243	0.168740548	0.000637367
139	7	3.23482E+18	13.39929715	5.19966E-05	0.999882982	5.94247E-05	2.599160305	1.12659E+20	1.50974E+22	6.54749E-05	0.0018	0.000129138	0.169918013	0.000641814
140	7	3.23482E+18	13.39929225	5.19966E-05	0.999882529	5.94247E-05	2.599160051	1.12659E+20	1.5202E+22	6.59286E-05	0.0018	0.000130032	0.171094842	0.000646259
141	7	3.23482E+18	13.39928734	5.19966E-05	0.999882075	5.94247E-05	2.599159796	1.12659E+20	1.53065E+22	6.6382E-05	0.0018	0.000130926	0.172271037	0.000650702
142	7	3.23482E+18	13.39928244	5.19965E-05	0.999881621	5.94246E-05	2.599159542	1.12659E+20	1.5411E+22	6.68352E-05	0.0018	0.000131819	0.173446597	0.000655142
143	7	3.23482E+18	13.39927754	5.19965E-05	0.999881168	5.94246E-05	2.599159287	1.12658E+20	1.55155E+22	6.72882E-05	0.0018	0.000132712	0.174621523	0.00065958
144	7	3.23482E+18	13.39927265	5.19965E-05	0.999880715	5.94246E-05	2.599159033	1.12658E+20	1.56199E+22	6.77409E-05	0.0018	0.000133605	0.175795816	0.000664016
145	7	3.23482E+18	13.39926776	5.19965E-05	0.999880263	5.94245E-05	2.599158779	1.12658E+20	1.57242E+22	6.81934E-05	0.0018	0.000134497	0.176969475	0.000668449
146	7	3.23482E+18	13.39926286	5.19965E-05	0.99987981	5.94245E-05	2.599158525	1.12658E+20	1.58284E+22	6.86456E-05	0.0018	0.000135388	0.178142502	0.00067288
147	7	3.23482E+18	13.39925798	5.19964E-05	0.999879358	5.94245E-05	2.599158272	1.12658E+20	1.59327E+22	6.90976E-05	0.0018	0.000136279	0.179314896	0.000677308
148	7	3.23482E+18	13.39925309	5.19964E-05	0.999878906	5.94245E-05	2.599158018	1.12658E+20	1.60368E+22	6.95493E-05	0.0018	0.00013717	0.180486657	0.000681734
149	7	3.23482E+18	13.39924821	5.19964E-05	0.999878454	5.94244E-05	2.599157765	1.12658E+20	1.61409E+22	7.00008E-05	0.0018	0.00013806	0.181657787	0.000686158
150	7	3.23482E+18	13.39924333	5.19964E-05	0.999878003	5.94244E-05	2.599157511	1.12658E+20	1.6245E+22	7.04521E-05	0.0018	0.000138949	0.182828285	0.000690579
151	7	3.23482E+18	13.39923845	5.19963E-05	0.999877552	5.94244E-05	2.599157258	1.12658E+20	1.6349E+22	7.09031E-05	0.0018	0.000139839	0.183998152	0.000694998
152	7	3.23482E+18	13.39923357	5.19963E-05	0.999877101	5.94244E-05	2.599157005	1.12658E+20	1.64529E+22	7.13539E-05	0.0018	0.000140727	0.185167388	0.000699414
153	7	3.23482E+18	13.3992287	5.19963E-05	0.99987665	5.94243E-05	2.599156752	1.12658E+20	1.65568E+22	7.18045E-05	0.0018	0.000141615	0.186335993	0.000703828
154	7	3.23482E+18	13.39922383	5.19963E-05	0.999876199	5.94243E-05	2.5991565	1.12658E+20	1.66606E+22	7.22548E-05	0.0018	0.000142503	0.187503969	0.00070824
155	7	3.23482E+18	13.39921897	5.19962E-05	0.999875749	5.94243E-05	2.599156247	1.12658E+20	1.67644E+22	7.27048E-05	0.0018	0.00014339	0.188671314	0.000712649
156	7	3.23482E+18	13.3992141	5.19962E-05	0.999875299	5.94243E-05	2.599155994	1.12658E+20	1.68681E+22	7.31547E-05	0.0018	0.000144277	0.18983803	0.000717056
157	7	3.23482E+18	13.39920924	5.19962E-05	0.999874849	5.94242E-05	2.599155742	1.12658E+20	1.69718E+22	7.36043E-05	0.0018	0.000145163	0.191004117	0.000721461
158	7	3.23482E+18	13.39920438	5.19962E-05	0.9998744	5.94242E-05	2.59915549	1.12658E+20	1.70754E+22	7.40536E-05	0.0018	0.000146049	0.192169575	0.000725863
159	7	3.23482E+18	13.39919952	5.19961E-05	0.99987395	5.94242E-05	2.599155238	1.12658E+20	1.71789E+22	7.45027E-05	0.0018	0.000146934	0.193334404	0.000730263
160	7	3.23482E+18	13.39919467	5.19961E-05	0.999873501	5.94241E-05	2.599154986	1.12658E+20	1.72824E+22	7.49516E-05	0.0018	0.000147819	0.194498606	0.00073466
161	7	3.23482E+18	13.39918982	5.19961E-05	0.999873052	5.94241E-05	2.599154734	1.12658E+20	1.73858E+22	7.54002E-05	0.0018	0.000148703	0.19566218	0.000739055
162	7	3.23482E+18	13.39918497	5.19961E-05	0.999872604	5.94241E-05	2.599154482	1.12657E+20	1.74892E+22	7.58486E-05	0.0018	0.000149587	0.196825126	0.000743448
163	7	3.23482E+18	13.39918012	5.19961E-05	0.999872155	5.94241E-05	2.599154231	1.12657E+20	1.75926E+22	7.62967E-05	0.0018	0.00015047	0.197987445	0.000747838
164	7	3.23482E+18	13.39917528	5.1996E-05	0.999871707	5.9424E-05	2.599153979	1.12657E+20	1.76958E+22	7.67447E-05	0.0018	0.000151353	0.199149138	0.000752226
165	7	3.23482E+18	13.39917043	5.1996E-05	0.999871259	5.9424E-05	2.599153728	1.12657E+20	1.77991E+22	7.71923E-05	0.0018	0.000152236	0.200310204	0.000756612
166	7	3.23482E+18	13.3991656	5.1996E-05	0.999870812	5.9424E-05	2.599153477	1.12657E+20	1.79022E+22	7.76398E-05	0.0018	0.000153118	0.201470644	0.000760995
167	7	3.23482E+18	13.39916076	5.1996E-05	0.999870364	5.9424E-05	2.599153226	1.12657E+20	1.80053E+22	7.8087E-05	0.0018	0.000153999	0.202630459	0.000765376
168	7	3.23482E+18	13.39915593	5.19959E-05	0.999869917	5.94239E-05	2.599152975	1.12657E+20	1.81084E+22	7.85339E-05	0.0018	0.00015488	0.203789648	0.000769754
169	7	3.23482E+18	13.3991511	5.19959E-05	0.99986947	5.94239E-05	2.599152724	1.12657E+20	1.82114E+22	7.89806E-05	0.0018	0.000155761	0.204948212	0.00077413
170	7	3.23482E+18	13.39914627	5.19959E-05	0.999869023	5.94239E-05	2.599152474	1.12657E+20	1.83143E+22	7.94271E-05	0.0018	0.000156641	0.206106151	0.000778504
171	7	3.23482E+18	13.39914144	5.19959E-05	0.999868577	5.94239E-05	2.599152223	1.12657E+20	1.84172E+22	7.98734E-05	0.0018	0.00015752	0.207263466	0.000782876
172	7	3.23482E+18	13.39913662	5.19958E-05	0.999868131	5.94238E-05	2.599151973	1.12657E+20	1.852E+22	8.03194E-05	0.0018	0.000158399	0.208420158	0.000787245
173	7	3.23482E+18	13.3991318	5.19958E-05	0.999867685	5.94238E-05	2.599151722	1.12657E+20	1.86228E+22	8.07651E-05	0.0018	0.000159278	0.209576225	0.000791611
174	7	3.23482E+18	13.39912698	5.19958E-05	0.999867239	5.94238E-05	2.599151472	1.12657E+20	1.87255E+22	8.12107E-05	0.0018	0.000160156	0.21073167	0.000795976
175	7	3.23482E+18	13.39912216	5.19958E-05	0.999866794	5.94237E-05	2.599151222	1.12657E+20	1.88282E+22	8.1656E-05	0.0018	0.000161034	0.211886491	0.000800338
176	7	3.23482E+18	13.39911735	5.19958E-05	0.999866348	5.94237E-05	2.599150973	1.12657E+20	1.89308E+22	8.2101E-05	0.0018	0.000161911	0.21304069	0.000804697
177	7	3.23482E+18	13.39911254	5.19957E-05	0.999865903	5.94237E-05	2.599150723	1.12657E+20	1.90334E+22	8.25458E-05	0.0018	0.000162788	0.214194266	0.000809055
178	7	3.23482E+18	13.39910773	5.19957E-05	0.999865458	5.94237E-05	2.599150473	1.12657E+20	1.91359E+22	8.29904E-05	0.0018	0.000163664	0.215347221	0.00081341
179	7	3.23482E+18	13.39910293	5.19957E-05	0.999865014	5.94236E-05	2.599150224	1.12657E+20	1.92383E+22	8.34348E-05	0.0018	0.00016454	0.216499554	0.000817762
180	7	3.23482E+18	13.39909812	5.19957E-05	0.99986457	5.94236E-05	2.599149975	1.12657E+20	1.93407E+22	8.38789E-05	0.0018	0.000165415	0.217651266	0.000822112
181	7	3.23482E+18	13.39909332	5.19956E-05	0.999864125	5.94236E-05	2.599149725	1.12657E+20	1.94431E+22	8.43228E-05	0.0018	0.00016629	0.218802357	0.00082646
182	7	3.23482E+18	13.39908853	5.19956E-05	0.999863682	5.94236E-05	2.599149476	1.12656E+20	1.95454E+22	8.47664E-05	0.0018	0.000167164	0.219952827	0.000830806
183	7	3.23482E+18	13.39908373	5.19956E-05	0.999863238	5.94235E-05	2.599149228	1.12656E+20	1.96476E+22	8.52098E-05	0.0018	0.000168038	0.221102677	0.000835149
184	7	3.23482E+18	13.39907894	5.19956E-05	0.999862795	5.94235E-05	2.599148979	1.12656E+20	1.97498E+22	8.56529E-05	0.0018	0.000168911	0.222251907	0.00083949
185	7	3.23482E+18	13.39907415	5.19955E-05	0.999862352	5.94235E-05	2.59914873	1.12656E+20	1.98519E+22	8.60959E-05	0.0018	0.000169784	0.223400518	0.000843828
186	7	3.23482E+18	13.39906936	5.19955E-05	0.999861909	5.94235E-05	2.599148482	1.12656E+20	1.9954E+22	8.65386E-05	0.0018	0.000170657	0.22454851	0.000848165
187	7	3.23482E+18	13.39906458	5.19955E-05	0.999861466	5.94234E-05	2.599148233	1.12656E+20	2.0056E+22	8.6981E-05	0.0018	0.000171529	0.225695883	0.000852498
188	7	3.23482E+18	13.39905979	5.19955E-05	0.999861024	5.94234E-05	2.599147985	1.12656E+20	2.01579E+22	8.74232E-05	0.0018	0.0001724	0.226842637	0.00085683
189	7	3.23482E+18	13.39905501	5.19955E-05	0.999860581	5.94234E-05	2.599147737	1.12656E+20	2.02598E+22	8.78652E-05	0.0018	0.000173271	0.227988773	0.000861159
190	7	3.23482E+18	13.39905024	5.19954E-05	0.999860139	5.94233E-05	2.599147489	1.12656E+20	2.03617E+22	8.8307E-05	0.0018	0.000174142	0.229134291	0.000865486
191	7	3.23482E+18	13.39904546	5.19954E-05	0.999859698	5.94233E-05	2.599147241	1.12656E+20	2.04635E+22	8.87485E-05	0.0018	0.000175012	0.230279192	0.000869811
192	7	3.23482E+18	13.39904069	5.19954E-05	0.999859256	5.94233E-05	2.599146993	1.12656E+20	2.05652E+22	8.91898E-05	0.0018	0.000175882	0.231423476	0.000874133
193	7	3.23482E+18	13.39903592	5.19954E-05	0.999858815	5.94233E-05	2.599146746	1.12656E+20	2.06669E+22	8.96308E-05	0.0018	0.000176751	0.232567143	0.000878453
194	7	3.23482E+18	13.39903115	5.19953E-05	0.999858374	5.94232E-05	2.599146498	1.12656E+20	2.07685E+22	9.00716E-05	0.0018	0.00017762	0.233710193	0.00088277
195	7	3.23482E+18	13.39902639	5.19953E-05	0.999857933	5.94232E-05	2.599146251	1.12656E+20	2.08701E+22	9.05122E-05	0.0018	0.000178488	0.234852628	0.000887085
196	7	3.23482E+18	13.39902163	5.19953E-05	0.999857493	5.94232E-05	2.599146004	1.12656E+20	2.09717E+22	9.09525E-05	0.0018	0.000179356	0.235994446	0.000891398
197	7	3.23482E+18	13.39901687	5.19953E-05	0.999857052	5.94232E-05	2.599145757	1.12656E+20	2.10731E+22	9.13926E-05	0.0018	0.000180223	0.237135649	0.000895709
198	7	3.23482E+18	13.39901211	5.19952E-05	0.999856612	5.94231E-05	2.59914551	1.12656E+20	2.11745E+22	9.18325E-05	0.0018	0.00018109	0.238276237	0.000900017
199	7	3.23482E+18	13.39900736	5.19952E-05	0.999856172	5.94231E-05	2.599145263	1.12656E+20	2.12759E+22	9.22721E-05	0.0018	0.000181956	0.239416211	0.000904323
200	7	3.23482E+18	13.3990026	5.19952E-05	0.999855733	5.94231E-05	2.599145017	1.12656E+20	2.13772E+22	9.27115E-05	0.0018	0.000182822	0.240555569	0.000908626
201	7	3.23482E+18	13.39899786	5.19952E-05	0.999855293	5.94231E-05	2.59914477	1.12655E+20	2.14785E+22	9.31507E-05	0.0018	0.000183688	0.241694314	0.000912928
202	7	3.23482E+18	13.39899311	5.19952E-05	0.999854854	5.9423E-05	2.599144524	1.12655E+20	2.15797E+22	9.35896E-05	0.0018	0.000184553	0.242832445	0.000917227
203	7	3.23482E+18	13.39898836	5.19951E-05	0.999854415	5.9423E-05	2.599144277	1.12655E+20	2.16808E+22	9.40283E-05	0.0018	0.000185417	0.243969963	0.000921523
204	7	3.23482E+18	13.39898362	5.19951E-05	0.999853977	5.9423E-05	2.599144031	1.12655E+20	2.17819E+22	9.44668E-05	0.0018	0.000186281	0.245106867	0.000925818
205	7	3.23482E+18	13.39897888	5.19951E-05	0.999853538	5.9423E-05	2.599143785	1.12655E+20	2.18829E+22	9.4905E-05	0.0018	0.000187145	0.246243159	0.00093011
206	7	3.23482E+18	13.39897415	5.19951E-05	0.9998531	5.94229E-05	2.599143539	1.12655E+20	2.19839E+22	9.5343E-05	0.0018	0.000188008	0.247378838	0.000934399
207	7	3.23482E+18	13.39896941	5.1995E-05	0.999852662	5.94229E-05	2.599143294	1.12655E+20	2.20849E+22	9.57808E-05	0.0018	0.000188871	0.248513905	0.000938687
208	7	3.23482E+18	13.39896468	5.1995E-05	0.999852224	5.94229E-05	2.599143048	1.12655E+20	2.21857E+22	9.62183E-05	0.0018	0.000189733	0.249648361	0.000942972
209	7	3.23482E+18	13.39895995	5.1995E-05	0.999851787	5.94229E-05	2.599142803	1.12655E+20	2.22866E+22	9.66556E-05	0.0018	0.000190594	0.250782205	0.000947255
210	7	3.23482E+18	13.39895523	5.1995E-05	0.999851349	5.94228E-05	2.599142557	1.12655E+20	2.23873E+22	9.70927E-05	0.0018	0.000191456	0.251915438	0.000951535
211	7	3.23482E+18	13.3989505	5.1995E-05	0.999850912	5.94228E-05	2.599142312	1.12655E+20	2.2488E+22	9.75295E-05	0.0018	0.000192317	0.25304806	0.000955813
212	7	3.23482E+18	13.39894578	5.19949E-05	0.999850476	5.94228E-05	2.599142067	1.12655E+20	2.25887E+22	9.79661E-05	0.0018	0.000193177	0.254180072	0.000960089
213	7	3.23482E+18	13.39894106	5.19949E-05	0.999850039	5.94227E-05	2.599141822	1.12655E+20	2.26893E+22	9.84025E-05	0.0018	0.000194037	0.255311474	0.000964362
214	7	3.23482E+18	13.39893635	5.19949E-05	0.999849603	5.94227E-05	2.599141577	1.12655E+20	2.27899E+22	9.88386E-05	0.0018	0.000194896	0.256442266	0.000968634

215	7	3.23482E+18	13.39893163	5.19949E-05	0.999849167	5.94227E-05	2.599141333	1.12655E+20	2.28904E+22	9.92745E-05	0.0018	0.000195755	0.257572449	0.000972903
216	7	3.23482E+18	13.39892692	5.19948E-05	0.999848731	5.94227E-05	2.599141088	1.12655E+20	2.29908E+22	9.97102E-05	0.0018	0.000196614	0.258702023	0.000977169
217	7	3.23482E+18	13.39892221	5.19948E-05	0.999848295	5.94226E-05	2.599140844	1.12655E+20	2.30912E+22	0.000100146	0.0018	0.000197472	0.259830988	0.000981434
218	7	3.23482E+18	13.3989175	5.19948E-05	0.99984786	5.94226E-05	2.599140599	1.12655E+20	2.31915E+22	0.000100581	0.0018	0.000198329	0.260959344	0.000985696
219	7	3.23482E+18	13.3989128	5.19948E-05	0.999847424	5.94226E-05	2.599140355	1.12655E+20	2.32918E+22	0.000101016	0.0018	0.000199186	0.262087093	0.000989955
220	7	3.23482E+18	13.3989081	5.19947E-05	0.999846989	5.94226E-05	2.599140111	1.12655E+20	2.33921E+22	0.000101451	0.0018	0.000200043	0.263214234	0.000994213
221	7	3.23482E+18	13.3989034	5.19947E-05	0.999846555	5.94225E-05	2.599139867	1.12654E+20	2.34922E+22	0.000101885	0.0018	0.000200899	0.264340767	0.000998468
222	7	3.23482E+18	13.3988987	5.19947E-05	0.99984612	5.94225E-05	2.599139623	1.12654E+20	2.35924E+22	0.000102319	0.0018	0.000201755	0.265466694	0.001002721
223	7	3.23482E+18	13.39889401	5.19947E-05	0.999845686	5.94225E-05	2.59913938	1.12654E+20	2.36924E+22	0.000102753	0.0018	0.00020261	0.266592014	0.001006971
224	7	3.23482E+18	13.39888932	5.19947E-05	0.999845252	5.94225E-05	2.599139136	1.12654E+20	2.37925E+22	0.000103187	0.0018	0.000203465	0.267716727	0.00101122
225	7	3.23482E+18	13.39888463	5.19946E-05	0.999844818	5.94224E-05	2.599138893	1.12654E+20	2.38924E+22	0.000103621	0.0018	0.000204319	0.268840834	0.001015466
226	7	3.23482E+18	13.39887994	5.19946E-05	0.999844385	5.94224E-05	2.59913865	1.12654E+20	2.39923E+22	0.000104054	0.0018	0.000205173	0.269964336	0.001019709
227	7	3.23482E+18	13.39887526	5.19946E-05	0.999843951	5.94224E-05	2.599138406	1.12654E+20	2.40922E+22	0.000104487	0.0018	0.000206026	0.271087232	0.001023951
228	7	3.23482E+18	13.39887058	5.19946E-05	0.999843518	5.94224E-05	2.599138163	1.12654E+20	2.4192E+22	0.00010492	0.0018	0.000206879	0.272209523	0.00102819
229	7	3.23482E+18	13.3988659	5.19945E-05	0.999843085	5.94223E-05	2.599137921	1.12654E+20	2.42918E+22	0.000105353	0.0018	0.000207732	0.27333121	0.001032427
230	7	3.23482E+18	13.39886122	5.19945E-05	0.999842653	5.94223E-05	2.599137678	1.12654E+20	2.43915E+22	0.000105785	0.0018	0.000208584	0.274452292	0.001036661
231	7	3.23482E+18	13.39885655	5.19945E-05	0.99984222	5.94223E-05	2.599137435	1.12654E+20	2.44911E+22	0.000106217	0.0018	0.000209435	0.27557277	0.001040893
232	7	3.23482E+18	13.39885188	5.19945E-05	0.999841788	5.94223E-05	2.599137193	1.12654E+20	2.45907E+22	0.000106649	0.0018	0.000210286	0.276692644	0.001045123
233	7	3.23482E+18	13.39884721	5.19945E-05	0.999841356	5.94222E-05	2.59913695	1.12654E+20	2.46902E+22	0.000107081	0.0018	0.000211137	0.277811915	0.001049351
234	7	3.23482E+18	13.39884254	5.19944E-05	0.999840924	5.94222E-05	2.599136708	1.12654E+20	2.47897E+22	0.000107513	0.0018	0.000211987	0.278930583	0.001053577
235	7	3.23482E+18	13.39883788	5.19944E-05	0.999840493	5.94222E-05	2.599136466	1.12654E+20	2.48891E+22	0.000107944	0.0018	0.000212837	0.280048649	0.0010578
236	7	3.23482E+18	13.39883322	5.19944E-05	0.999840062	5.94222E-05	2.599136224	1.12654E+20	2.49885E+22	0.000108375	0.0018	0.000213686	0.281166111	0.001062021
237	7	3.23482E+18	13.39882856	5.19944E-05	0.999839631	5.94221E-05	2.599135982	1.12654E+20	2.50879E+22	0.000108806	0.0018	0.000214535	0.282282972	0.001066239
238	7	3.23482E+18	13.3988239	5.19943E-05	0.9998392	5.94221E-05	2.599135741	1.12654E+20	2.51871E+22	0.000109236	0.0018	0.000215383	0.283399231	0.001070456
239	7	3.23482E+18	13.39881925	5.19943E-05	0.999838769	5.94221E-05	2.599135499	1.12654E+20	2.52864E+22	0.000109667	0.0018	0.000216231	0.284514889	0.00107467
240	7	3.23482E+18	13.3988146	5.19943E-05	0.999838339	5.94221E-05	2.599135258	1.12654E+20	2.53855E+22	0.000110097	0.0018	0.000217079	0.285629945	0.001078881
241	7	3.23482E+18	13.39880995	5.19943E-05	0.999837909	5.9422E-05	2.599135016	1.12653E+20	2.54846E+22	0.000110527	0.0018	0.000217926	0.286744401	0.001083091
242	7	3.23482E+18	13.3988053	5.19943E-05	0.999837479	5.9422E-05	2.599134775	1.12653E+20	2.55837E+22	0.000110956	0.0018	0.000218772	0.287858257	0.001087298
243	7	3.23482E+18	13.39880066	5.19942E-05	0.999837049	5.9422E-05	2.599134534	1.12653E+20	2.56827E+22	0.000111386	0.0018	0.000219618	0.288971512	0.001091503
244	7	3.23482E+18	13.39879602	5.19942E-05	0.99983662	5.9422E-05	2.599134293	1.12653E+20	2.57817E+22	0.000111815	0.0018	0.000220464	0.290084167	0.001095706
245	7	3.23482E+18	13.39879138	5.19942E-05	0.999836191	5.94219E-05	2.599134052	1.12653E+20	2.58806E+22	0.000112244	0.0018	0.000221309	0.291196224	0.001099906
246	7	3.23482E+18	13.39878674	5.19942E-05	0.999835762	5.94219E-05	2.599133812	1.12653E+20	2.59794E+22	0.000112673	0.0018	0.000222154	0.292307681	0.001104105
247	7	3.23482E+18	13.39878211	5.19941E-05	0.999835333	5.94219E-05	2.599133571	1.12653E+20	2.60782E+22	0.000113101	0.0018	0.000222998	0.293418539	0.001108301
248	7	3.23482E+18	13.39877748	5.19941E-05	0.999834905	5.94218E-05	2.599133331	1.12653E+20	2.6177E+22	0.00011353	0.0018	0.000223842	0.294528799	0.001112494
249	7	3.23482E+18	13.39877285	5.19941E-05	0.999834476	5.94218E-05	2.59913309	1.12653E+20	2.62757E+22	0.000113958	0.0018	0.000224685	0.295638461	0.001116686
250	7	3.23482E+18	13.39876822	5.19941E-05	0.999834048	5.94218E-05	2.59913285	1.12653E+20	2.63743E+22	0.000114386	0.0018	0.000225528	0.296747525	0.001120875
251	7	3.23482E+18	13.3987636	5.19941E-05	0.99983362	5.94218E-05	2.59913261	1.12653E+20	2.64729E+22	0.000114813	0.0018	0.000226371	0.297855991	0.001125062
252	7	3.23482E+18	13.39875897	5.1994E-05	0.999833193	5.94217E-05	2.59913237	1.12653E+20	2.65714E+22	0.000115241	0.0018	0.000227213	0.298963861	0.001129246
253	7	3.23482E+18	13.39875435	5.1994E-05	0.999832765	5.94217E-05	2.59913213	1.12653E+20	2.66699E+22	0.000115668	0.0018	0.000228054	0.300071133	0.001133429
254	7	3.23482E+18	13.39874974	5.1994E-05	0.999832338	5.94217E-05	2.599131891	1.12653E+20	2.67683E+22	0.000116095	0.0018	0.000228895	0.30117781	0.001137609
255	7	3.23482E+18	13.39874512	5.1994E-05	0.999831911	5.94217E-05	2.599131651	1.12653E+20	2.68667E+22	0.000116521	0.0018	0.000229736	0.30228389	0.001141787
256	7	3.23482E+18	13.39874051	5.19939E-05	0.999831485	5.94216E-05	2.599131412	1.12653E+20	2.6965E+22	0.000116948	0.0018	0.000230576	0.303389374	0.001145962
257	7	3.23482E+18	13.3987359	5.19939E-05	0.999831058	5.94216E-05	2.599131172	1.12653E+20	2.70633E+22	0.000117374	0.0018	0.000231416	0.304494263	0.001150136
258	7	3.23482E+18	13.3987313	5.19939E-05	0.999830632	5.94216E-05	2.599130933	1.12653E+20	2.71615E+22	0.0001178	0.0018	0.000232255	0.305598556	0.001154307
259	7	3.23482E+18	13.39872669	5.19939E-05	0.999830206	5.94216E-05	2.599130694	1.12653E+20	2.72597E+22	0.000118226	0.0018	0.000233094	0.306702255	0.001158476
260	7	3.23482E+18	13.39872209	5.19939E-05	0.99982978	5.94215E-05	2.599130455	1.12653E+20	2.73578E+22	0.000118652	0.0018	0.000233932	0.307805359	0.001162642
261	7	3.23482E+18	13.39871749	5.19938E-05	0.999829355	5.94215E-05	2.599130217	1.12653E+20	2.74559E+22	0.000119077	0.0018	0.00023477	0.308907869	0.001166807
262	7	3.23482E+18	13.39871289	5.19938E-05	0.999828929	5.94215E-05	2.599129978	1.12652E+20	2.75539E+22	0.000119502	0.0018	0.000235607	0.310009786	0.001170969
263	7	3.23482E+18	13.3987083	5.19938E-05	0.999828504	5.94215E-05	2.599129739	1.12652E+20	2.76519E+22	0.000119927	0.0018	0.000236444	0.311111109	0.001175129
264	7	3.23482E+18	13.39870371	5.19938E-05	0.999828079	5.94214E-05	2.599129501	1.12652E+20	2.77498E+22	0.000120352	0.0018	0.000237281	0.312211838	0.001179287
265	7	3.23482E+18	13.39869912	5.19937E-05	0.999827655	5.94214E-05	2.599129263	1.12652E+20	2.78476E+22	0.000120776	0.0018	0.000238117	0.313311975	0.001183442
266	7	3.23482E+18	13.39869453	5.19937E-05	0.99982723	5.94214E-05	2.599129025	1.12652E+20	2.79454E+22	0.0001212	0.0018	0.000238953	0.314411519	0.001187595
267	7	3.23482E+18	13.39868994	5.19937E-05	0.999826806	5.94214E-05	2.599128787	1.12652E+20	2.80432E+22	0.000121624	0.0018	0.000239788	0.315510471	0.001191746
268	7	3.23482E+18	13.39868536	5.19937E-05	0.999826382	5.94213E-05	2.599128549	1.12652E+20	2.81409E+22	0.000122048	0.0018	0.000240623	0.316608831	0.001195895
269	7	3.23482E+18	13.39868078	5.19937E-05	0.999825958	5.94213E-05	2.599128311	1.12652E+20	2.82385E+22	0.000122472	0.0018	0.000241457	0.317706599	0.001200041
270	7	3.23482E+18	13.3986762	5.19936E-05	0.999825535	5.94213E-05	2.599128073	1.12652E+20	2.83361E+22	0.000122895	0.0018	0.000242291	0.318803776	0.001204186
271	7	3.23482E+18	13.39867163	5.19936E-05	0.999825112	5.94213E-05	2.599127836	1.12652E+20	2.84337E+22	0.000123318	0.0018	0.000243124	0.319900363	0.001208328
272	7	3.23482E+18	13.39866706	5.19936E-05	0.999824689	5.94212E-05	2.599127599	1.12652E+20	2.85311E+22	0.000123741	0.0018	0.000243957	0.320996358	0.001212467
273	7	3.23482E+18	13.39866249	5.19936E-05	0.999824266	5.94212E-05	2.599127361	1.12652E+20	2.86286E+22	0.000124163	0.0018	0.00024479	0.322091764	0.001216605
274	7	3.23482E+18	13.39865792	5.19935E-05	0.999823843	5.94212E-05	2.599127124	1.12652E+20	2.8726E+22	0.000124586	0.0018	0.000245622	0.323186579	0.00122074
275	7	3.23482E+18	13.39865335	5.19935E-05	0.999823421	5.94212E-05	2.599126887	1.12652E+20	2.88233E+22	0.000125008	0.0018	0.000246453	0.324280805	0.001224873
276	7	3.23482E+18	13.39864879	5.19935E-05	0.999822999	5.94211E-05	2.59912665	1.12652E+20	2.89206E+22	0.00012543	0.0018	0.000247285	0.325374442	0.001229004
277	7	3.23482E+18	13.39864423	5.19935E-05	0.999822577	5.94211E-05	2.599126414	1.12652E+20	2.90178E+22	0.000125852	0.0018	0.000248115	0.326467489	0.001233133
278	7	3.23482E+18	13.39863967	5.19935E-05	0.999822155	5.94211E-05	2.599126177	1.12652E+20	2.9115E+22	0.000126273	0.0018	0.000248946	0.327559948	0.001237259
279	7	3.23482E+18	13.39863511	5.19934E-05	0.999821733	5.94211E-05	2.59912594	1.12652E+20	2.92121E+22	0.000126694	0.0018	0.000249775	0.328651819	0.001241384
280	7	3.23482E+18	13.39863056	5.19934E-05	0.999821312	5.9421E-05	2.599125704	1.12652E+20	2.93092E+22	0.000127116	0.0018	0.000250605	0.329743102	0.001245506
281	7	3.23482E+18	13.39862601	5.19934E-05	0.999820891	5.9421E-05	2.599125468	1.12652E+20	2.94062E+22	0.000127536	0.0018	0.000251434	0.330833796	0.001249625
282	7	3.23482E+18	13.39862146	5.19934E-05	0.99982047	5.9421E-05	2.599125232	1.12651E+20	2.95032E+22	0.000127957	0.0018	0.000252262	0.331923904	0.001253743
283	7	3.23482E+18	13.39861692	5.19933E-05	0.99982005	5.9421E-05	2.599124996	1.12651E+20	2.96001E+22	0.000128377	0.0018	0.00025309	0.333013424	0.001257858
284	7	3.23482E+18	13.39861237	5.19933E-05	0.999819629	5.94209E-05	2.59912476	1.12651E+20	2.9697E+22	0.000128798	0.0018	0.000253918	0.334102358	0.001261971
285	7	3.23482E+18	13.39860783	5.19933E-05	0.999819209	5.94209E-05	2.599124524	1.12651E+20	2.97938E+22	0.000129217	0.0018	0.000254745	0.335190706	0.001266082
286	7	3.23482E+18	13.39860329	5.19933E-05	0.999818789	5.94209E-05	2.599124289	1.12651E+20	2.98906E+22	0.000129637	0.0018	0.000255572	0.336278467	0.001270191
287	7	3.23482E+18	13.39859876	5.19933E-05	0.99981837	5.94209E-05	2.599124053	1.12651E+20	2.99873E+22	0.000130057	0.0018	0.000256398	0.337365643	0.001274298
288	7	3.23482E+18	13.39859422	5.19932E-05	0.99981795	5.94208E-05	2.599123818	1.12651E+20	3.00839E+22	0.000130476	0.0018	0.000257224	0.338452233	0.001278402
289	7	3.23482E+18	13.39858969	5.19932E-05	0.999817531	5.94208E-05	2.599123582	1.12651E+20	3.01805E+22	0.000130895	0.0018	0.000258049	0.339538238	0.001282504
290	7	3.23482E+18	13.39858516	5.19932E-05	0.999817112	5.94208E-05	2.599123347	1.12651E+20	3.02771E+22	0.000131314	0.0018	0.000258874	0.340623658	0.001286604
291	7	3.23482E+18	13.39858064	5.19932E-05	0.999816693	5.94208E-05	2.599123112	1.12651E+20	3.03736E+22	0.000131732	0.0018	0.000259698	0.341708494	0.001290701
292	7	3.23482E+18	13.39857611	5.19931E-05	0.999816274	5.94207E-05	2.599122878	1.12651E+20	3.04701E+22	0.000132151	0.0018	0.000260522	0.342792745	0.001294797
293	7	3.23482E+18	13.39857159	5.19931E-05	0.999815856	5.94207E-05	2.599122643	1.12651E+20	3.05665E+22	0.000132569	0.0018	0.000261346	0.343876413	0.00129889
294	7	3.23482E+18	13.39856707	5.19931E-05	0.999815438	5.94207E-05	2.599122408	1.12651E+20	3.06628E+22	0.000132987	0.0018	0.000262169	0.344959497	0.001302981
295	7	3.23482E+18	13.39856255	5.19931E-05	0.99981502	5.94207E-05	2.599122174	1.12651E+20	3.07591E+22	0.000133405	0.0018	0.000262992	0.346041999	0.00130707
296	7	3.23482E+18	13.39855804	5.19931E-05	0.999814602	5.94206E-05	2.599121939	1.12651E+20	3.08554E+22	0.000133822	0.0018	0.000263814	0.347123917	0.001311156
297	7	3.23482E+18	13.39855353	5.1993E-05	0.999814185	5.94206E-05	2.599121705	1.12651E+20	3.09516E+22	0.000134239	0.0018	0.000264636	0.348205253	0.001315241
298	7	3.23482E+18	13.39854902	5.1993E-05	0.999813768	5.94206E-05	2.599121471	1.12651E+20	3.10477E+22	0.000134656	0.0018	0.000265457	0.349286006	0.001319323
299	7	3.23482E+18	13.39854451	5.1993E-05	0.999813351	5.94206E-05	2.599121237	1.12651E+20	3.11438E+22	0.000135073	0.0018	0.000266278	0.350366178	0.001323403
300	7	3.23482E+18	13.39854001	5.1993E-05	0.999812934	5.94205E-05	2.599121003	1.12651E+20	3.12399E+22	0.00013549	0.0018	0.000267099	0.351445768	0.001327481
301	7	3.23482E+18	13.3985355	5.1993E-05	0.999812517	5.94205E-05	2.599120769	1.12651E+20	3.13358E+22	0.000135906	0.0018	0.000267919	0.352524776	0.001331557
302	7	3.23482E+18	13.398531	5.19929E-05	0.999812101	5.94205E-05	2.599120536	1.12651E+20	3.14318E+22	0.000136322	0.0018	0.000268738	0.353603204	0.00133563
303	7	3.23482E+18	13.39852651	5.19929E-05	0.999811685	5.94205E-05	2.599120302	1.1265E+20	3.15277E+22	0.000136738	0.0018	0.000269558	0.354681051	0.001339701
304	7	3.23482E+18	13.39852201	5.19929E-05	0.999811269	5.94204E-05	2.599120069	1.1265E+20	3.16235E+22	0.000137154	0.0018	0.000270376	0.355758318	0.00134377
305	7	3.23482E+18	13.39851752	5.19929E-05	0.999810853	5.94204E-05	2.599119836	1.1265E+20	3.17193E+22	0.00013757	0.0018	0.000271195	0.356835005	0.001347837
306	7	3.23482E+18	13.39851303	5.19928E-05	0.999810438	5.94204E-05	2.599119603	1.1265E+20	3.1815E+22	0.000137985	0.0018	0.000272012	0.357911112	0.001351902
307	7	3.23482E+18	13.39850854	5.19928E-05	0.999810022	5.94204E-05	2.59911937	1.1265E+20	3.19107E+22	0.0001384	0.0018	0.00027283	0.35898664	0.001355964
308	7	3.23482E+18	13.39850405	5.19928E-05	0.999809607	5.94203E-05	2.599119137	1.1265E+20	3.20064E+22	0.000138815	0.0018	0.000273647	0.360061589	0.001360025
309	7	3.23482E+18	13.39849957	5.19928E-05	0.999809193	5.94203E-05	2.599118904	1.1265E+20	3.2102E+22	0.000139229	0.0018	0.000274463	0.361135959	0.001364083
310	7	3.23482E+18	13.39849509	5.19928E-05	0.999808778	5.94203E-05	2.599118671	1.1265E+20	3.21975E+22	0.000139644	0.0018	0.000275279	0.36220975	0.001368139
311	7	3.23482E+18	13.39849061	5.19927E-05	0.999808364	5.94203E-05	2.599118439	1.1265E+20	3.2293E+22	0.000140058	0.0018	0.000276095	0.363282964	0.001372192
312	7	3.23482E+18	13.39848613	5.19927E-05	0.999807949	5.94202E-05	2.599118207	1.1265E+20	3.23884E+22	0.000140472	0.0018	0.00027691	0.3643556	0.001376244
313	7	3.23482E+18	13.39848166	5.19927E-05	0.999807536	5.94202E-05	2.599117974	1.1265E+20	3.24838E+22	0.000140885	0.0018	0.000277725	0.365427658	0.001380293
314	7	3.23482E+18	13.39847719	5.19927E-05	0.999807122	5.94202E-05	2.599117742	1.1265E+20	3.25791E+22	0.000141299	0.0018	0.000278539	0.366499139	0.001384341
315	7	3.23482E+18	13.39847272	5.19927E-05	0.999806708	5.94202E-05	2.59911751	1.1265E+20	3.26744E+22	0.000141712	0.0018	0.000279353	0.367570043	0.001388386
316	7	3.23482E+18	13.39846825	5.19926E-05	0.999806295	5.94201E-05	2.599117278	1.1265E+20	3.27696E+22	0.000142125	0.0018	0.000280167	0.368640371	0.001392428
317	7	3.23482E+18	13.39846379	5.19926E-05	0.999805882	5.94201E-05	2.599117047	1.1265E+20	3.28648E+22	0.000142538	0.0018	0.00028098	0.369710123	0.001396469
318	7	3.23482E+18	13.39845933	5.19926E-05	0.999805469	5.94201E-05	2.599116815	1.1265E+20	3.29599E+22	0.000142951	0.0018	0.000281792	0.370779299	0.001400508
319	7	3.23482E+18	13.39845487	5.19926E-05	0.999805057	5.94201E-05	2.599116583	1.1265E+20	3.3055E+22	0.000143363	0.0018	0.000282604	0.371847899	0.001404544
320	7	3.23482E+18	13.39845041	5.19925E-05	0.999804644	5.94201E-05	2.599116352	1.1265E+20	3.315E+22	0.000143775	0.0018	0.000283416	0.372915924	0.001408578
321	7	3.23482E+18	13.39844596	5.19925E-05	0.999804232	5.942E-05	2.599116121	1.1265E+20	3.3245E+22	0.000144187	0.0018	0.000284227	0.373983374	0.00141261
322	7	3.23482E+18	13.3984415	5.19925E-05	0.99980382	5.942E-05	2.59911589	1.1265E+20	3.33399E+22	0.000144599	0.0018	0.000285038	0.37505025	0.00141664
323	7	3.23482E+18	13.39843705	5.19925E-05	0.999803408	5.942E-05	2.599115659	1.1265E+20	3.34348E+22	0.000145011	0.0018	0.000285849	0.376116551	0.001420667
324	7	3.23482E+18	13.39843261	5.19925E-05	0.999802997	5.942E-05	2.599115428	1.12649E+20	3.35296E+22	0.000145422	0.0018	0.000286659	0.377182278	0.001424693
325	7	3.23482E+18	13.39842816	5.19924E-05	0.999802586	5.94199E-05	2.599115197	1.12649E+20	3.36244E+22	0.000145833	0.0018	0.000287468	0.378247431	0.001428716
326	7	3.23482E+18	13.39842372	5.19924E-05	0.999802175	5.94199E-05	2.599114966	1.12649E+20	3.37191E+22	0.000146244	0.0018	0.000288277	0.379312012	0.001432737
327	7	3.23482E+18	13.39841928	5.19924E-05	0.999801764	5.94199E-05	2.599114736	1.12649E+20	3.38138E+22	0.000146655	0.0018	0.000289086	0.380376019	0.001436756
328	7	3.23482E+18	13.39841484	5.19924E-05	0.999801353	5.94199E-05	2.599114505	1.12649E+20	3.39084E+22	0.000147065	0.0018	0.000289894	0.381439453	0.001440773
329	7	3.23482E+18	13.3984104	5.19924E-05	0.999800943	5.94198E-05	2.599114275	1.12649E+20	3.4003E+22	0.000147475	0.0018	0.000290702	0.382502315	0.001444788
330	7	3.23482E+18	13.39840597	5.19923E-05	0.999800532	5.94198E-05	2.599114045	1.12649E+20	3.40975E+22	0.000147885	0.0018	0.000291509	0.383564605	0.0014488
331	7	3.23482E+18	13.39840154	5.19923E-05	0.999800123	5.94198E-05	2.599113815	1.12649E+20	3.4192E+22	0.000148295	0.0018	0.000292316	0.384626323	0.001452811
332	7	3.23482E+18	13.39839711	5.19923E-05	0.999799713	5.94198E-05	2.599113585	1.12649E+20	3.42864E+22	0.000148705	0.0018	0.000293122	0.38568747	0.001456819
333	7	3.23482E+18	13.39839268	5.19923E-05	0.999799303	5.94197E-05	2.599113355	1.12649E+20	3.43808E+22	0.000149114	0.0018	0.000293929	0.386748045	0.001460825
334	7	3.23482E+18	13.39838826	5.19922E-05	0.999798894	5.94197E-05	2.599113126	1.12649E+20	3.44751E+22	0.000149523	0.0018	0.000294734	0.38780805	0.001464829
335	7	3.23482E+18	13.39838384	5.19922E-05	0.999798485	5.94197E-05	2.599112896	1.12649E+20	3.45693E+22	0.000149932	0.0018	0.000295539	0.388867484	0.00146883
336	7	3.23482E+18	13.39837942	5.19922E-05	0.999798076	5.94197E-05	2.599112667	1.12649E+20	3.46636E+22	0.000150341	0.0018	0.000296344	0.389926348	0.00147283
337	7	3.23482E+18	13.398375	5.19922E-05	0.999797667	5.94196E-05	2.599112437	1.12649E+20	3.47577E+22	0.000150749	0.0018	0.000297148	0.390984642	0.001476827
338	7	3.23482E+18	13.39837059	5.19922E-05	0.999797259	5.94196E-05	2.599112208	1.12649E+20	3.48519E+22	0.000151157	0.0018	0.000297952	0.392042367	0.001480822
339	7	3.23482E+18	13.39836618	5.19921E-05	0.999796851	5.94196E-05	2.599111979	1.12649E+20	3.49459E+22	0.000151565	0.0018	0.000298756	0.393099522	0.001484816
340	7	3.23482E+18	13.39836177	5.19921E-05	0.999796443	5.94196E-05	2.59911175	1.12649E+20	3.50399E+22	0.000151973	0.0018	0.000299559	0.394156108	0.001488806
341	7	3.23482E+18	13.39835736	5.19921E-05	0.999796035	5.94195E-05	2.599111521	1.12649E+20	3.51339E+22	0.000152381	0.0018	0.000300361	0.395212126	0.001492795
342	7	3.23482E+18	13.39835295	5.19921E-05	0.999795627	5.94195E-05	2.599111293	1.12649E+20	3.52278E+22	0.000152788	0.0018	0.000301163	0.396267575	0.001496782

343	7	3.23482E+18	13.39834855	5.19921E-05	0.99979522	5.94195E-05	2.599111064	1.12649E+20	3.53217E+22	0.000153195	0.0018	0.000301965	0.397322456	0.001500766
344	7	3.23482E+18	13.39834415	5.1992E-05	0.999794813	5.94195E-05	2.599110836	1.12649E+20	3.54155E+22	0.000153602	0.0018	0.000302766	0.39837677	0.001504749
345	7	3.23482E+18	13.39833975	5.1992E-05	0.999794406	5.94194E-05	2.599110607	1.12648E+20	3.55093E+22	0.000154009	0.0018	0.000303567	0.399430516	0.001508729
346	7	3.23482E+18	13.39833536	5.1992E-05	0.999793999	5.94194E-05	2.599110379	1.12648E+20	3.5603E+22	0.000154415	0.0018	0.000304368	0.400483695	0.001512707
347	7	3.23482E+18	13.39833096	5.1992E-05	0.999793593	5.94194E-05	2.599110151	1.12648E+20	3.56967E+22	0.000154822	0.0018	0.000305168	0.401536307	0.001516683
348	7	3.23482E+18	13.39832657	5.19919E-05	0.999793186	5.94194E-05	2.599109923	1.12648E+20	3.57903E+22	0.000155228	0.0018	0.000305967	0.402588353	0.001520657
349	7	3.23482E+18	13.39832218	5.19919E-05	0.99979278	5.94193E-05	2.599109695	1.12648E+20	3.58838E+22	0.000155634	0.0018	0.000306766	0.403639832	0.001524628
350	7	3.23482E+18	13.3983178	5.19919E-05	0.999792374	5.94193E-05	2.599109467	1.12648E+20	3.59774E+22	0.000156039	0.0018	0.000307565	0.404690746	0.001528598
351	7	3.23482E+18	13.39831341	5.19919E-05	0.999791969	5.94193E-05	2.59910924	1.12648E+20	3.60708E+22	0.000156445	0.0018	0.000308363	0.405741094	0.001532565
352	7	3.23482E+18	13.39830903	5.19919E-05	0.999791563	5.94193E-05	2.599109012	1.12648E+20	3.61642E+22	0.00015685	0.0018	0.000309161	0.406790877	0.00153653
353	7	3.23482E+18	13.39830465	5.19918E-05	0.999791158	5.94193E-05	2.599108785	1.12648E+20	3.62576E+22	0.000157255	0.0018	0.000309958	0.407840095	0.001540494
354	7	3.23482E+18	13.39830028	5.19918E-05	0.999790753	5.94192E-05	2.599108558	1.12648E+20	3.63509E+22	0.00015766	0.0018	0.000310755	0.408888748	0.001544455
355	7	3.23482E+18	13.3982959	5.19918E-05	0.999790348	5.94192E-05	2.599108331	1.12648E+20	3.64442E+22	0.000158064	0.0018	0.000311552	0.409936837	0.001548413
356	7	3.23482E+18	13.39829153	5.19918E-05	0.999789944	5.94192E-05	2.599108104	1.12648E+20	3.65374E+22	0.000158469	0.0018	0.000312348	0.410984362	0.00155237
357	7	3.23482E+18	13.39828716	5.19918E-05	0.99978954	5.94192E-05	2.599107877	1.12648E+20	3.66306E+22	0.000158873	0.0018	0.000313144	0.412031324	0.001556325
358	7	3.23482E+18	13.39828279	5.19917E-05	0.999789135	5.94191E-05	2.59910765	1.12648E+20	3.67237E+22	0.000159277	0.0018	0.000313939	0.413077722	0.001560277
359	7	3.23482E+18	13.39827843	5.19917E-05	0.999788731	5.94191E-05	2.599107423	1.12648E+20	3.68168E+22	0.000159681	0.0018	0.000314734	0.414123557	0.001564227
360	7	3.23482E+18	13.39827406	5.19917E-05	0.999788328	5.94191E-05	2.599107197	1.12648E+20	3.69098E+22	0.000160084	0.0018	0.000315528	0.415168829	0.001568176
361	7	3.23482E+18	13.3982697	5.19917E-05	0.999787924	5.94191E-05	2.59910697	1.12648E+20	3.70028E+22	0.000160487	0.0018	0.000316322	0.416213539	0.001572122
362	7	3.23482E+18	13.39826534	5.19917E-05	0.999787521	5.9419E-05	2.599106744	1.12648E+20	3.70957E+22	0.00016089	0.0018	0.000317116	0.417257686	0.001576066
363	7	3.23482E+18	13.39826099	5.19916E-05	0.999787118	5.9419E-05	2.599106518	1.12648E+20	3.71886E+22	0.000161293	0.0018	0.000317909	0.418301272	0.001580008
364	7	3.23482E+18	13.39825663	5.19916E-05	0.999786715	5.9419E-05	2.599106292	1.12648E+20	3.72814E+22	0.000161696	0.0018	0.000318702	0.419344296	0.001583947
365	7	3.23482E+18	13.39825228	5.19916E-05	0.999786313	5.9419E-05	2.599106066	1.12648E+20	3.73742E+22	0.000162098	0.0018	0.000319494	0.420386759	0.001587885
366	7	3.23482E+18	13.39824793	5.19916E-05	0.99978591	5.94189E-05	2.59910584	1.12647E+20	3.74669E+22	0.0001625	0.0018	0.000320286	0.421428661	0.00159182
367	7	3.23482E+18	13.39824359	5.19915E-05	0.999785508	5.94189E-05	2.599105615	1.12647E+20	3.75595E+22	0.000162902	0.0018	0.000321077	0.422470003	0.001595754
368	7	3.23482E+18	13.39823924	5.19915E-05	0.999785106	5.94189E-05	2.599105389	1.12647E+20	3.76522E+22	0.000163304	0.0018	0.000321868	0.423510784	0.001599685
369	7	3.23482E+18	13.3982349	5.19915E-05	0.999784704	5.94189E-05	2.599105164	1.12647E+20	3.77447E+22	0.000163706	0.0018	0.000322659	0.424551005	0.001603614
370	7	3.23482E+18	13.39823056	5.19915E-05	0.999784303	5.94188E-05	2.599104938	1.12647E+20	3.78373E+22	0.000164107	0.0018	0.000323449	0.425590667	0.001607541
371	7	3.23482E+18	13.39822622	5.19915E-05	0.999783901	5.94188E-05	2.599104713	1.12647E+20	3.79297E+22	0.000164508	0.0018	0.000324239	0.426629769	0.001611466
372	7	3.23482E+18	13.39822189	5.19914E-05	0.9997835	5.94188E-05	2.599104488	1.12647E+20	3.80222E+22	0.000164909	0.0018	0.000325028	0.427668312	0.001615389
373	7	3.23482E+18	13.39821755	5.19914E-05	0.999783099	5.94188E-05	2.599104263	1.12647E+20	3.81146E+22	0.00016531	0.0018	0.000325817	0.428706296	0.001619309
374	7	3.23482E+18	13.39821322	5.19914E-05	0.999782699	5.94187E-05	2.599104038	1.12647E+20	3.82069E+22	0.00016571	0.0018	0.000326605	0.429743722	0.001623228
375	7	3.23482E+18	13.3982089	5.19914E-05	0.999782298	5.94187E-05	2.599103814	1.12647E+20	3.82992E+22	0.000166111	0.0018	0.000327393	0.43078059	0.001627144
376	7	3.23482E+18	13.39820457	5.19914E-05	0.999781898	5.94187E-05	2.599103589	1.12647E+20	3.83914E+22	0.000166511	0.0018	0.000328181	0.431816899	0.001631059
377	7	3.23482E+18	13.39820025	5.19913E-05	0.999781498	5.94187E-05	2.599103365	1.12647E+20	3.84836E+22	0.000166911	0.0018	0.000328968	0.432852652	0.001634971
378	7	3.23482E+18	13.39819592	5.19913E-05	0.999781098	5.94187E-05	2.59910314	1.12647E+20	3.85757E+22	0.00016731	0.0018	0.000329755	0.433887847	0.001638881
379	7	3.23482E+18	13.39819161	5.19913E-05	0.999780698	5.94186E-05	2.599102916	1.12647E+20	3.86678E+22	0.00016771	0.0018	0.000330541	0.434922485	0.001642789
380	7	3.23482E+18	13.39818729	5.19913E-05	0.999780299	5.94186E-05	2.599102692	1.12647E+20	3.87598E+22	0.000168109	0.0018	0.000331327	0.435956566	0.001646695
381	7	3.23482E+18	13.39818297	5.19913E-05	0.9997799	5.94186E-05	2.599102468	1.12647E+20	3.88518E+22	0.000168508	0.0018	0.000332112	0.436990092	0.001650599
382	7	3.23482E+18	13.39817866	5.19912E-05	0.999779501	5.94186E-05	2.599102244	1.12647E+20	3.89437E+22	0.000168907	0.0018	0.000332898	0.438023061	0.001654501
383	7	3.23482E+18	13.39817435	5.19912E-05	0.999779102	5.94185E-05	2.59910202	1.12647E+20	3.90356E+22	0.000169305	0.0018	0.000333682	0.439055474	0.0016584
384	7	3.23482E+18	13.39817004	5.19912E-05	0.999778703	5.94185E-05	2.599101797	1.12647E+20	3.91275E+22	0.000169704	0.0018	0.000334466	0.440087332	0.001662298
385	7	3.23482E+18	13.39816574	5.19912E-05	0.999778305	5.94185E-05	2.599101573	1.12647E+20	3.92192E+22	0.000170102	0.0018	0.00033525	0.441118635	0.001666193
386	7	3.23482E+18	13.39816144	5.19912E-05	0.999777907	5.94185E-05	2.59910135	1.12647E+20	3.9311E+22	0.0001705	0.0018	0.000336034	0.442149383	0.001670087
387	7	3.23482E+18	13.39815714	5.19911E-05	0.999777509	5.94184E-05	2.599101126	1.12647E+20	3.94027E+22	0.000170898	0.0018	0.000336816	0.443179577	0.001673978
388	7	3.23482E+18	13.39815284	5.19911E-05	0.999777111	5.94184E-05	2.599100903	1.12646E+20	3.94943E+22	0.000171295	0.0018	0.000337599	0.444209217	0.001677867
389	7	3.23482E+18	13.39814854	5.19911E-05	0.999776714	5.94184E-05	2.59910068	1.12646E+20	3.95859E+22	0.000171692	0.0018	0.000338381	0.445238302	0.001681754
390	7	3.23482E+18	13.39814425	5.19911E-05	0.999776317	5.94184E-05	2.599100457	1.12646E+20	3.96775E+22	0.000172089	0.0018	0.000339163	0.446266834	0.001685639
391	7	3.23482E+18	13.39813996	5.19911E-05	0.999775919	5.94183E-05	2.599100235	1.12646E+20	3.97689E+22	0.000172486	0.0018	0.000339944	0.447294813	0.001689522
392	7	3.23482E+18	13.39813567	5.1991E-05	0.999775523	5.94183E-05	2.599100012	1.12646E+20	3.98604E+22	0.000172883	0.0018	0.000340725	0.448322239	0.001693403
393	7	3.23482E+18	13.39813138	5.1991E-05	0.999775126	5.94183E-05	2.599099789	1.12646E+20	3.99518E+22	0.00017328	0.0018	0.000341505	0.449349112	0.001697281
394	7	3.23482E+18	13.3981271	5.1991E-05	0.999774729	5.94183E-05	2.599099567	1.12646E+20	4.00431E+22	0.000173676	0.0018	0.000342285	0.450375432	0.001701158
395	7	3.23482E+18	13.39812281	5.1991E-05	0.999774333	5.94183E-05	2.599099344	1.12646E+20	4.01344E+22	0.000174072	0.0018	0.000343065	0.451401201	0.001705033
396	7	3.23482E+18	13.39811853	5.19909E-05	0.999773937	5.94182E-05	2.599099122	1.12646E+20	4.02257E+22	0.000174468	0.0018	0.000343844	0.452426418	0.001708905
397	7	3.23482E+18	13.39811425	5.19909E-05	0.999773541	5.94182E-05	2.5990989	1.12646E+20	4.03169E+22	0.000174863	0.0018	0.000344623	0.453451083	0.001712775
398	7	3.23482E+18	13.39810998	5.19909E-05	0.999773146	5.94182E-05	2.599098678	1.12646E+20	4.04081E+22	0.000175259	0.0018	0.000345401	0.454475197	0.001716644
399	7	3.23482E+18	13.39810571	5.19909E-05	0.99977275	5.94182E-05	2.599098456	1.12646E+20	4.04992E+22	0.000175654	0.0018	0.000346179	0.455498761	0.00172051
400	7	3.23482E+18	13.39810144	5.19909E-05	0.999772355	5.94181E-05	2.599098235	1.12646E+20	4.05902E+22	0.000176049	0.0018	0.000346957	0.456521773	0.001724374
401	7	3.23482E+18	13.39809717	5.19908E-05	0.99977196	5.94181E-05	2.599098013	1.12646E+20	4.06812E+22	0.000176444	0.0018	0.000347734	0.457544236	0.001728236
402	7	3.23482E+18	13.3980929	5.19908E-05	0.999771566	5.94181E-05	2.599097791	1.12646E+20	4.07722E+22	0.000176838	0.0018	0.00034851	0.458566149	0.001732096
403	7	3.23482E+18	13.39808864	5.19908E-05	0.999771171	5.94181E-05	2.59909757	1.12646E+20	4.08631E+22	0.000177233	0.0018	0.000349287	0.459587511	0.001735954
404	7	3.23482E+18	13.39808437	5.19908E-05	0.999770777	5.9418E-05	2.599097349	1.12646E+20	4.0954E+22	0.000177627	0.0018	0.000350062	0.460608325	0.00173981
405	7	3.23482E+18	13.39808011	5.19908E-05	0.999770382	5.9418E-05	2.599097128	1.12646E+20	4.10448E+22	0.000178021	0.0018	0.000350838	0.46162859	0.001743664
406	7	3.23482E+18	13.39807586	5.19907E-05	0.999769989	5.9418E-05	2.599096907	1.12646E+20	4.11355E+22	0.000178414	0.0018	0.000351613	0.462648305	0.001747515
407	7	3.23482E+18	13.3980716	5.19907E-05	0.999769595	5.9418E-05	2.599096686	1.12646E+20	4.12263E+22	0.000178808	0.0018	0.000352387	0.463667473	0.001751365
408	7	3.23482E+18	13.39806735	5.19907E-05	0.999769201	5.94179E-05	2.599096465	1.12646E+20	4.13169E+22	0.000179201	0.0018	0.000353161	0.464686092	0.001755212
409	7	3.23482E+18	13.3980631	5.19907E-05	0.999768808	5.94179E-05	2.599096244	1.12646E+20	4.14075E+22	0.000179594	0.0018	0.000353935	0.465704163	0.001759058
410	7	3.23482E+18	13.39805885	5.19907E-05	0.999768415	5.94179E-05	2.599096024	1.12645E+20	4.14981E+22	0.000179987	0.0018	0.000354708	0.466721687	0.001762901
411	7	3.23482E+18	13.3980546	5.19906E-05	0.999768022	5.94179E-05	2.599095803	1.12645E+20	4.15886E+22	0.00018038	0.0018	0.000355481	0.467738663	0.001766742
412	7	3.23482E+18	13.39805036	5.19906E-05	0.999767629	5.94179E-05	2.599095583	1.12645E+20	4.16791E+22	0.000180772	0.0018	0.000356254	0.468755093	0.001770582
413	7	3.23482E+18	13.39804612	5.19906E-05	0.999767237	5.94178E-05	2.599095363	1.12645E+20	4.17695E+22	0.000181165	0.0018	0.000357026	0.469770976	0.001774419
414	7	3.23482E+18	13.39804188	5.19906E-05	0.999766845	5.94178E-05	2.599095143	1.12645E+20	4.18599E+22	0.000181557	0.0018	0.000357798	0.470786312	0.001778254
415	7	3.23482E+18	13.39803764	5.19906E-05	0.999766453	5.94178E-05	2.599094923	1.12645E+20	4.19503E+22	0.000181949	0.0018	0.000358569	0.471801103	0.001782087
416	7	3.23482E+18	13.39803341	5.19905E-05	0.999766061	5.94178E-05	2.599094703	1.12645E+20	4.20405E+22	0.00018234	0.0018	0.00035934	0.472815347	0.001785918
417	7	3.23482E+18	13.39802918	5.19905E-05	0.999765669	5.94177E-05	2.599094483	1.12645E+20	4.21308E+22	0.000182732	0.0018	0.00036011	0.473829047	0.001789747
418	7	3.23482E+18	13.39802495	5.19905E-05	0.999765278	5.94177E-05	2.599094263	1.12645E+20	4.2221E+22	0.000183123	0.0018	0.00036088	0.474842201	0.001793574
419	7	3.23482E+18	13.39802072	5.19905E-05	0.999764887	5.94177E-05	2.599094044	1.12645E+20	4.23111E+22	0.000183514	0.0018	0.00036165	0.47585481	0.001797399
420	7	3.23482E+18	13.39801649	5.19905E-05	0.999764496	5.94177E-05	2.599093824	1.12645E+20	4.24012E+22	0.000183905	0.0018	0.000362419	0.476866875	0.001801222
421	7	3.23482E+18	13.39801227	5.19904E-05	0.999764105	5.94176E-05	2.599093605	1.12645E+20	4.24912E+22	0.000184295	0.0018	0.000363188	0.477878395	0.001805042
422	7	3.23482E+18	13.39800805	5.19904E-05	0.999763714	5.94176E-05	2.599093386	1.12645E+20	4.25812E+22	0.000184686	0.0018	0.000363956	0.478889371	0.001808861
423	7	3.23482E+18	13.39800383	5.19904E-05	0.999763324	5.94176E-05	2.599093167	1.12645E+20	4.26712E+22	0.000185076	0.0018	0.000364724	0.479899804	0.001812678
424	7	3.23482E+18	13.39799961	5.19904E-05	0.999762934	5.94176E-05	2.599092948	1.12645E+20	4.27611E+22	0.000185466	0.0018	0.000365491	0.480909694	0.001816492
425	7	3.23482E+18	13.3979954	5.19904E-05	0.999762544	5.94175E-05	2.599092729	1.12645E+20	4.28509E+22	0.000185856	0.0018	0.000366258	0.48191904	0.001820305
426	7	3.23482E+18	13.39799119	5.19903E-05	0.999762154	5.94175E-05	2.599092511	1.12645E+20	4.29407E+22	0.000186245	0.0018	0.000367025	0.482927843	0.001824115
427	7	3.23482E+18	13.39798698	5.19903E-05	0.999761765	5.94175E-05	2.599092292	1.12645E+20	4.30305E+22	0.000186635	0.0018	0.000367791	0.483936105	0.001827923
428	7	3.23482E+18	13.39798277	5.19903E-05	0.999761375	5.94175E-05	2.599092074	1.12645E+20	4.31202E+22	0.000187024	0.0018	0.000368557	0.484943823	0.00183173
429	7	3.23482E+18	13.39797856	5.19903E-05	0.999760986	5.94175E-05	2.599091855	1.12645E+20	4.32099E+22	0.000187413	0.0018	0.000369323	0.485951	0.001835534
430	7	3.23482E+18	13.39797436	5.19903E-05	0.999760597	5.94174E-05	2.599091637	1.12645E+20	4.32995E+22	0.000187801	0.0018	0.000370088	0.486957636	0.001839336
431	7	3.23482E+18	13.39797016	5.19902E-05	0.999760208	5.94174E-05	2.599091419	1.12645E+20	4.3389E+22	0.00018819	0.0018	0.000370852	0.48796373	0.001843137
432	7	3.23482E+18	13.39796596	5.19902E-05	0.99975982	5.94174E-05	2.599091201	1.12644E+20	4.34786E+22	0.000188578	0.0018	0.000371617	0.488969283	0.001846935
433	7	3.23482E+18	13.39796176	5.19902E-05	0.999759432	5.94174E-05	2.599090983	1.12644E+20	4.3568E+22	0.000188966	0.0018	0.00037238	0.489974295	0.001850731
434	7	3.23482E+18	13.39795757	5.19902E-05	0.999759044	5.94173E-05	2.599090765	1.12644E+20	4.36574E+22	0.000189354	0.0018	0.000373144	0.490978767	0.001854525
435	7	3.23482E+18	13.39795338	5.19902E-05	0.999758656	5.94173E-05	2.599090548	1.12644E+20	4.37468E+22	0.000189742	0.0018	0.000373907	0.491982699	0.001858317
436	7	3.23482E+18	13.39794919	5.19901E-05	0.999758268	5.94173E-05	2.59909033	1.12644E+20	4.38362E+22	0.000190129	0.0018	0.000374669	0.492986091	0.001862107
437	7	3.23482E+18	13.397945	5.19901E-05	0.99975788	5.94173E-05	2.599090113	1.12644E+20	4.39254E+22	0.000190517	0.0018	0.000375432	0.493988944	0.001865895
438	7	3.23482E+18	13.39794081	5.19901E-05	0.999757493	5.94172E-05	2.599089895	1.12644E+20	4.40147E+22	0.000190904	0.0018	0.000376193	0.494991257	0.001869681
439	7	3.23482E+18	13.39793663	5.19901E-05	0.999757106	5.94172E-05	2.599089678	1.12644E+20	4.41038E+22	0.000191291	0.0018	0.000376955	0.495993032	0.001873465
440	7	3.23482E+18	13.39793245	5.19901E-05	0.999756719	5.94172E-05	2.599089461	1.12644E+20	4.4193E+22	0.000191677	0.0018	0.000377716	0.496994267	0.001877247
441	7	3.23482E+18	13.39792827	5.199E-05	0.999756333	5.94172E-05	2.599089244	1.12644E+20	4.42821E+22	0.000192064	0.0018	0.000378476	0.497994965	0.001881027
442	7	3.23482E+18	13.3979241	5.199E-05	0.999755946	5.94172E-05	2.599089027	1.12644E+20	4.43711E+22	0.00019245	0.0018	0.000379236	0.498995124	0.001884804
443	7	3.23482E+18	13.39791992	5.199E-05	0.99975556	5.94171E-05	2.599088811	1.12644E+20	4.44601E+22	0.000192836	0.0018	0.000379996	0.499994746	0.00188858
444	7	3.23482E+18	13.39791575	5.199E-05	0.999755174	5.94171E-05	2.599088594	1.12644E+20	4.4549E+22	0.000193222	0.0018	0.000380755	0.50099383	0.001892354
445	7	3.23482E+18	13.39791158	5.199E-05	0.999754788	5.94171E-05	2.599088377	1.12644E+20	4.46379E+22	0.000193608	0.0018	0.000381514	0.501992377	0.001896126
446	7	3.23482E+18	13.39790741	5.19899E-05	0.999754403	5.94171E-05	2.599088161	1.12644E+20	4.47268E+22	0.000193993	0.0018	0.000382273	0.502990387	0.001899895
447	7	3.23482E+18	13.39790325	5.19899E-05	0.999754017	5.9417E-05	2.599087945	1.12644E+20	4.48156E+22	0.000194378	0.0018	0.000383031	0.503987861	0.001903663
448	7	3.23482E+18	13.39789908	5.19899E-05	0.999753632	5.9417E-05	2.599087729	1.12644E+20	4.49044E+22	0.000194763	0.0018	0.000383788	0.504984798	0.001907429
449	7	3.23482E+18	13.39789492	5.19899E-05	0.999753247	5.9417E-05	2.599087513	1.12644E+20	4.49931E+22	0.000195148	0.0018	0.000384546	0.505981199	0.001911192
450	7	3.23482E+18	13.39789076	5.19899E-05	0.999752862	5.9417E-05	2.599087297	1.12644E+20	4.50817E+22	0.000195533	0.0018	0.000385303	0.506977065	0.001914954
451	7	3.23482E+18	13.39788661	5.19898E-05	0.999752477	5.9417E-05	2.599087081	1.12644E+20	4.51703E+22	0.000195917	0.0018	0.000386059	0.507972395	0.001918713
452	7	3.23482E+18	13.39788245	5.19898E-05	0.999752093	5.94169E-05	2.599086865	1.12644E+20	4.52589E+22	0.000196301	0.0018	0.000386815	0.50896719	0.001922471
453	7	3.23482E+18	13.3978783	5.19898E-05	0.999751709	5.94169E-05	2.59908665	1.12644E+20	4.53474E+22	0.000196685	0.0018	0.000387571	0.509961451	0.001926226
454	7	3.23482E+18	13.39787415	5.19898E-05	0.999751325	5.94169E-05	2.599086434	1.12644E+20	4.54359E+22	0.000197069	0.0018	0.000388326	0.510955176	0.00192998
455	7	3.23482E+18	13.39787	5.19898E-05	0.999750941	5.94169E-05	2.599086219	1.12643E+20	4.55243E+22	0.000197453	0.0018	0.000389081	0.511948368	0.001933731
456	7	3.23482E+18	13.39786586	5.19897E-05	0.999750558	5.94168E-05	2.599086004	1.12643E+20	4.56127E+22	0.000197836	0.0018	0.000389835	0.512941025	0.001937481
457	7	3.23482E+18	13.39786172	5.19897E-05	0.999750174	5.94168E-05	2.599085788	1.12643E+20	4.5701E+22	0.000198219	0.0018	0.000390589	0.513933149	0.001941228
458	7	3.23482E+18	13.39785758	5.19897E-05	0.999749791	5.94168E-05	2.599085573	1.12643E+20	4.57893E+22	0.000198602	0.0018	0.000391343	0.51492474	0.001944974
459	7	3.23482E+18	13.39785344	5.19897E-05	0.999749408	5.94168E-05	2.599085359	1.12643E+20	4.58776E+22	0.000198985	0.0018	0.000392096	0.515915798	0.001948717
460	7	3.23482E+18	13.3978493	5.19897E-05	0.999749025	5.94167E-05	2.599085144	1.12643E+20	4.59658E+22	0.000199368	0.0018	0.000392849	0.516906322	0.001952459
461	7	3.23482E+18	13.39784517	5.19896E-05	0.999748643	5.94167E-05	2.599084929	1.12643E+20	4.60539E+22	0.00019975	0.0018	0.000393601	0.517896315	0.001956198
462	7	3.23482E+18	13.39784103	5.19896E-05	0.99974826	5.94167E-05	2.599084715	1.12643E+20	4.6142E+22	0.000200132	0.0018	0.000394353	0.518885775	0.001959935
463	7	3.23482E+18	13.3978369	5.19896E-05	0.999747878	5.94167E-05	2.5990845	1.12643E+20	4.62301E+22	0.000200514	0.0018	0.000395105	0.519874703	0.001963671
464	7	3.23482E+18	13.39783278	5.19896E-05	0.999747496	5.94167E-05	2.599084286	1.12643E+20	4.63181E+22	0.000200896	0.0018	0.000395856	0.520863099	0.001967404
465	7	3.23482E+18	13.39782865	5.19896E-05	0.999747115	5.94166E-05	2.599084072	1.12643E+20	4.6406E+22	0.000201277	0.0018	0.000396607	0.521850965	0.001971135
466	7	3.23482E+18	13.39782453	5.19895E-05	0.999746733	5.94166E-05	2.599083858	1.12643E+20	4.64939E+22	0.000201659	0.0018	0.000397357	0.522838299	0.001974865
467	7	3.23482E+18	13.39782041	5.19895E-05	0.999746352	5.94166E-05	2.599083644	1.12643E+20	4.65818E+22	0.00020204	0.0018	0.000398107	0.523825102	0.001978592
468	7	3.23482E+18	13.39781629	5.19895E-05	0.999745971	5.94166E-05	2.59908343	1.12643E+20	4.66696E+22	0.000202421	0.0018	0.000398857	0.524811376	0.001982318
469	7	3.23482E+18	13.39781217	5.19895E-05	0.99974559	5.94165E-05	2.599083216	1.12643E+20	4.67574E+22	0.000202802	0.0018	0.000399606	0.525797118	0.001986041
470	7	3.23482E+18	13.39780806	5.19895E-05	0.999745209	5.94165E-05	2.599083002	1.12643E+20	4.68451E+22	0.000203182	0.0018	0.000400355	0.526782332	0.001989762

471	7	3.23482E+18	13.39780394	5.19894E-05	0.999744828	5.94165E-05	2.599082789	1.12643E+20	4.69328E+22	0.000203562	0.0018	0.000401103	0.527767015	0.001993482
472	7	3.23482E+18	13.39779983	5.19894E-05	0.999744448	5.94165E-05	2.599082575	1.12643E+20	4.70204E+22	0.000203943	0.0018	0.000401851	0.528751169	0.001997199
473	7	3.23482E+18	13.39779573	5.19894E-05	0.999744068	5.94165E-05	2.599082362	1.12643E+20	4.7108E+22	0.000204323	0.0018	0.000402598	0.529734794	0.002000914
474	7	3.23482E+18	13.39779162	5.19894E-05	0.999743688	5.94164E-05	2.599082149	1.12643E+20	4.71955E+22	0.000204702	0.0018	0.000403346	0.530717891	0.002004628
475	7	3.23482E+18	13.39778752	5.19894E-05	0.999743308	5.94164E-05	2.599081936	1.12643E+20	4.7283E+22	0.000205082	0.0018	0.000404092	0.531700459	0.002008339
476	7	3.23482E+18	13.39778341	5.19893E-05	0.999742929	5.94164E-05	2.599081723	1.12643E+20	4.73704E+22	0.000205461	0.0018	0.000404839	0.532682499	0.002012048
477	7	3.23482E+18	13.39777932	5.19893E-05	0.99974255	5.94164E-05	2.59908151	1.12643E+20	4.74578E+22	0.00020584	0.0018	0.000405585	0.533664011	0.002015756
478	7	3.23482E+18	13.39777522	5.19893E-05	0.99974217	5.94163E-05	2.599081297	1.12642E+20	4.75452E+22	0.000206219	0.0018	0.00040633	0.534644996	0.002019461
479	7	3.23482E+18	13.39777112	5.19893E-05	0.999741792	5.94163E-05	2.599081085	1.12642E+20	4.76325E+22	0.000206598	0.0018	0.000407075	0.535625453	0.002023164
480	7	3.23482E+18	13.39776703	5.19893E-05	0.999741413	5.94163E-05	2.599080872	1.12642E+20	4.77197E+22	0.000206976	0.0018	0.00040782	0.536605383	0.002026866
481	7	3.23482E+18	13.39776294	5.19892E-05	0.999741034	5.94163E-05	2.59908066	1.12642E+20	4.7807E+22	0.000207355	0.0018	0.000408564	0.537584787	0.002030565
482	7	3.23482E+18	13.39775885	5.19892E-05	0.999740656	5.94162E-05	2.599080448	1.12642E+20	4.78941E+22	0.000207733	0.0018	0.000409308	0.538563664	0.002034263
483	7	3.23482E+18	13.39775477	5.19892E-05	0.999740278	5.94162E-05	2.599080235	1.12642E+20	4.79812E+22	0.000208111	0.0018	0.000410052	0.539542015	0.002037958
484	7	3.23482E+18	13.39775068	5.19892E-05	0.9997399	5.94162E-05	2.599080023	1.12642E+20	4.80683E+22	0.000208488	0.0018	0.000410795	0.54051984	0.002041652
485	7	3.23482E+18	13.3977466	5.19892E-05	0.999739522	5.94162E-05	2.599079811	1.12642E+20	4.81553E+22	0.000208866	0.0018	0.000411538	0.54149714	0.002045343
486	7	3.23482E+18	13.39774252	5.19891E-05	0.999739145	5.94162E-05	2.5990796	1.12642E+20	4.82423E+22	0.000209243	0.0018	0.00041228	0.542473915	0.002049032
487	7	3.23482E+18	13.39773844	5.19891E-05	0.999738768	5.94161E-05	2.599079388	1.12642E+20	4.83292E+22	0.00020962	0.0018	0.000413022	0.543450164	0.00205272
488	7	3.23482E+18	13.39773437	5.19891E-05	0.99973839	5.94161E-05	2.599079176	1.12642E+20	4.84161E+22	0.000209997	0.0018	0.000413764	0.544425889	0.002056405
489	7	3.23482E+18	13.39773029	5.19891E-05	0.999738014	5.94161E-05	2.599078965	1.12642E+20	4.8503E+22	0.000210374	0.0018	0.000414505	0.54540109	0.002060089
490	7	3.23482E+18	13.39772622	5.19891E-05	0.999737637	5.94161E-05	2.599078753	1.12642E+20	4.85897E+22	0.000210751	0.0018	0.000415246	0.546375766	0.002063771
491	7	3.23482E+18	13.39772216	5.1989E-05	0.99973726	5.9416E-05	2.599078542	1.12642E+20	4.86765E+22	0.000211127	0.0018	0.000415986	0.547349919	0.00206745
492	7	3.23482E+18	13.39771809	5.1989E-05	0.999736884	5.9416E-05	2.599078331	1.12642E+20	4.87632E+22	0.000211503	0.0018	0.000416726	0.548323548	0.002071128
493	7	3.23482E+18	13.39771402	5.1989E-05	0.999736508	5.9416E-05	2.59907812	1.12642E+20	4.88498E+22	0.000211879	0.0018	0.000417465	0.549296653	0.002074803
494	7	3.23482E+18	13.39770996	5.1989E-05	0.999736132	5.9416E-05	2.599077909	1.12642E+20	4.89365E+22	0.000212255	0.0018	0.000418205	0.550269236	0.002078477
495	7	3.23482E+18	13.3977059	5.1989E-05	0.999735756	5.9416E-05	2.599077698	1.12642E+20	4.9023E+22	0.00021263	0.0018	0.000418943	0.551241296	0.002082149
496	7	3.23482E+18	13.39770184	5.19889E-05	0.999735381	5.94159E-05	2.599077488	1.12642E+20	4.91095E+22	0.000213005	0.0018	0.000419682	0.552212834	0.002085818
497	7	3.23482E+18	13.39769779	5.19889E-05	0.999735006	5.94159E-05	2.599077277	1.12642E+20	4.9196E+22	0.000213381	0.0018	0.00042042	0.55318385	0.002089486
498	7	3.23482E+18	13.39769373	5.19889E-05	0.999734631	5.94159E-05	2.599077066	1.12642E+20	4.92824E+22	0.000213755	0.0018	0.000421157	0.554154344	0.002093152
499	7	3.23482E+18	13.39768968	5.19889E-05	0.999734256	5.94159E-05	2.599076856	1.12642E+20	4.93688E+22	0.00021413	0.0018	0.000421894	0.555124316	0.002096816
500	7	3.23482E+18	13.39768563	5.19889E-05	0.999733881	5.94158E-05	2.599076646	1.12642E+20	4.94551E+22	0.000214505	0.0018	0.000422631	0.556093767	0.002100477
501	7	3.23482E+18	13.39768159	5.19888E-05	0.999733506	5.94158E-05	2.599076436	1.12641E+20	4.95414E+22	0.000214879	0.0018	0.000423368	0.557062698	0.002104137
502	7	3.23482E+18	13.39767754	5.19888E-05	0.999733132	5.94158E-05	2.599076226	1.12641E+20	4.96277E+22	0.000215253	0.0018	0.000424104	0.558031107	0.002107795
503	7	3.23482E+18	13.3976735	5.19888E-05	0.999732758	5.94158E-05	2.599076016	1.12641E+20	4.97138E+22	0.000215627	0.0018	0.000424839	0.558998996	0.002111451
504	7	3.23482E+18	13.39766946	5.19888E-05	0.999732384	5.94158E-05	2.599075806	1.12641E+20	4.98E+22	0.000216001	0.0018	0.000425574	0.559966365	0.002115105
505	7	3.23482E+18	13.39766542	5.19888E-05	0.99973201	5.94157E-05	2.599075596	1.12641E+20	4.98861E+22	0.000216374	0.0018	0.000426309	0.560933214	0.002118757
506	7	3.23482E+18	13.39766138	5.19887E-05	0.999731637	5.94157E-05	2.599075387	1.12641E+20	4.99722E+22	0.000216748	0.0018	0.000427044	0.561899544	0.002122407
507	7	3.23482E+18	13.39765735	5.19887E-05	0.999731264	5.94157E-05	2.599075177	1.12641E+20	5.00582E+22	0.000217121	0.0018	0.000427778	0.562865354	0.002126055
508	7	3.23482E+18	13.39765332	5.19887E-05	0.999730891	5.94157E-05	2.599074968	1.12641E+20	5.01441E+22	0.000217494	0.0018	0.000428511	0.563830646	0.002129701
509	7	3.23482E+18	13.39764929	5.19887E-05	0.999730518	5.94156E-05	2.599074759	1.12641E+20	5.023E+22	0.000217866	0.0018	0.000429245	0.564795419	0.002133345
510	7	3.23482E+18	13.39764526	5.19887E-05	0.999730145	5.94156E-05	2.599074549	1.12641E+20	5.03159E+22	0.000218239	0.0018	0.000429977	0.565759673	0.002136987
511	7	3.23482E+18	13.39764123	5.19887E-05	0.999729772	5.94156E-05	2.59907434	1.12641E+20	5.04017E+22	0.000218611	0.0018	0.00043071	0.566723409	0.002140628
512	7	3.23482E+18	13.39763721	5.19886E-05	0.9997294	5.94156E-05	2.599074132	1.12641E+20	5.04875E+22	0.000218983	0.0018	0.000431442	0.567686627	0.002144266
513	7	3.23482E+18	13.39763319	5.19886E-05	0.999729028	5.94156E-05	2.599073923	1.12641E+20	5.05733E+22	0.000219355	0.0018	0.000432173	0.568649328	0.002147902
514	7	3.23482E+18	13.39762917	5.19886E-05	0.999728656	5.94155E-05	2.599073714	1.12641E+20	5.06589E+22	0.000219727	0.0018	0.000432905	0.569611512	0.002151537
515	7	3.23482E+18	13.39762515	5.19886E-05	0.999728284	5.94155E-05	2.599073505	1.12641E+20	5.07446E+22	0.000220099	0.0018	0.000433636	0.570573178	0.002155169
516	7	3.23482E+18	13.39762114	5.19886E-05	0.999727913	5.94155E-05	2.599073297	1.12641E+20	5.08302E+22	0.00022047	0.0018	0.000434366	0.571534328	0.002158799
517	7	3.23482E+18	13.39761713	5.19885E-05	0.999727542	5.94155E-05	2.599073089	1.12641E+20	5.09157E+22	0.000220841	0.0018	0.000435096	0.572494962	0.002162428
518	7	3.23482E+18	13.39761311	5.19885E-05	0.99972717	5.94154E-05	2.59907288	1.12641E+20	5.10012E+22	0.000221212	0.0018	0.000435826	0.573455079	0.002166055
519	7	3.23482E+18	13.39760911	5.19885E-05	0.9997268	5.94154E-05	2.599072672	1.12641E+20	5.10867E+22	0.000221583	0.0018	0.000436555	0.574414681	0.002169679
520	7	3.23482E+18	13.3976051	5.19885E-05	0.999726429	5.94154E-05	2.599072464	1.12641E+20	5.11721E+22	0.000221953	0.0018	0.000437284	0.575373766	0.002173302
521	7	3.23482E+18	13.3976011	5.19885E-05	0.999726058	5.94154E-05	2.599072256	1.12641E+20	5.12575E+22	0.000222324	0.0018	0.000438013	0.576332337	0.002176923
522	7	3.23482E+18	13.39759709	5.19884E-05	0.999725688	5.94154E-05	2.599072049	1.12641E+20	5.13428E+22	0.000222694	0.0018	0.000438741	0.577290393	0.002180541
523	7	3.23482E+18	13.39759309	5.19884E-05	0.999725318	5.94153E-05	2.599071841	1.12641E+20	5.14281E+22	0.000223064	0.0018	0.000439468	0.578247933	0.002184158
524	7	3.23482E+18	13.3975891	5.19884E-05	0.999724948	5.94153E-05	2.599071633	1.1264E+20	5.15133E+22	0.000223433	0.0018	0.000440196	0.57920496	0.002187773
525	7	3.23482E+18	13.3975851	5.19884E-05	0.999724578	5.94153E-05	2.599071426	1.1264E+20	5.15985E+22	0.000223803	0.0018	0.000440923	0.580161472	0.002191386
526	7	3.23482E+18	13.39758111	5.19884E-05	0.999724209	5.94153E-05	2.599071218	1.1264E+20	5.16837E+22	0.000224172	0.0018	0.000441649	0.58111747	0.002194997
527	7	3.23482E+18	13.39757712	5.19883E-05	0.999723839	5.94152E-05	2.599071011	1.1264E+20	5.17688E+22	0.000224542	0.0018	0.000442375	0.582072955	0.002198606
528	7	3.23482E+18	13.39757313	5.19883E-05	0.99972347	5.94152E-05	2.599070804	1.1264E+20	5.18538E+22	0.000224911	0.0018	0.000443101	0.583027927	0.002202213
529	7	3.23482E+18	13.39756914	5.19883E-05	0.999723101	5.94152E-05	2.599070597	1.1264E+20	5.19388E+22	0.000225279	0.0018	0.000443827	0.583982385	0.002205818
530	7	3.23482E+18	13.39756515	5.19883E-05	0.999722732	5.94152E-05	2.59907039	1.1264E+20	5.20238E+22	0.000225648	0.0018	0.000444552	0.584936331	0.002209422
531	7	3.23482E+18	13.39756117	5.19883E-05	0.999722364	5.94152E-05	2.599070183	1.1264E+20	5.21087E+22	0.000226016	0.0018	0.000445276	0.585889764	0.002213023
532	7	3.23482E+18	13.39755719	5.19882E-05	0.999721996	5.94151E-05	2.599069977	1.1264E+20	5.21936E+22	0.000226384	0.0018	0.000446	0.586842685	0.002216622
533	7	3.23482E+18	13.39755321	5.19882E-05	0.999721627	5.94151E-05	2.59906977	1.1264E+20	5.22784E+22	0.000226752	0.0018	0.000446724	0.587795094	0.00222022
534	7	3.23482E+18	13.39754923	5.19882E-05	0.999721259	5.94151E-05	2.599069563	1.1264E+20	5.23632E+22	0.00022712	0.0018	0.000447448	0.588746991	0.002223815
535	7	3.23482E+18	13.39754526	5.19882E-05	0.999720892	5.94151E-05	2.599069357	1.1264E+20	5.24479E+22	0.000227488	0.0018	0.000448171	0.589698377	0.002227409
536	7	3.23482E+18	13.39754129	5.19882E-05	0.999720524	5.94151E-05	2.599069151	1.1264E+20	5.25326E+22	0.000227855	0.0018	0.000448893	0.590649252	0.002231
537	7	3.23482E+18	13.39753732	5.19882E-05	0.999720157	5.9415E-05	2.599068945	1.1264E+20	5.26172E+22	0.000228222	0.0018	0.000449616	0.591599616	0.00223459
538	7	3.23482E+18	13.39753335	5.19881E-05	0.999719789	5.9415E-05	2.599068739	1.1264E+20	5.27018E+22	0.000228589	0.0018	0.000450338	0.592549469	0.002238178
539	7	3.23482E+18	13.39752938	5.19881E-05	0.999719422	5.9415E-05	2.599068533	1.1264E+20	5.27864E+22	0.000228956	0.0018	0.000451059	0.593498813	0.002241764
540	7	3.23482E+18	13.39752542	5.19881E-05	0.999719056	5.9415E-05	2.599068327	1.1264E+20	5.28709E+22	0.000229323	0.0018	0.00045178	0.594447646	0.002245348
541	7	3.23482E+18	13.39752146	5.19881E-05	0.999718689	5.94149E-05	2.599068121	1.1264E+20	5.29554E+22	0.000229689	0.0018	0.000452501	0.59539597	0.00224893
542	7	3.23482E+18	13.3975175	5.19881E-05	0.999718323	5.94149E-05	2.599067916	1.1264E+20	5.30398E+22	0.000230056	0.0018	0.000453221	0.596343784	0.00225251
543	7	3.23482E+18	13.39751354	5.1988E-05	0.999717956	5.94149E-05	2.59906771	1.1264E+20	5.31242E+22	0.000230422	0.0018	0.000453941	0.597291089	0.002256088
544	7	3.23482E+18	13.39750959	5.1988E-05	0.99971759	5.94149E-05	2.599067505	1.1264E+20	5.32085E+22	0.000230787	0.0018	0.000454661	0.598237885	0.002259664
545	7	3.23482E+18	13.39750563	5.1988E-05	0.999717225	5.94149E-05	2.599067299	1.1264E+20	5.32928E+22	0.000231153	0.0018	0.00045538	0.599184173	0.002263238
546	7	3.23482E+18	13.39750168	5.1988E-05	0.999716859	5.94148E-05	2.599067094	1.1264E+20	5.3377E+22	0.000231519	0.0018	0.000456099	0.600129952	0.002266811
547	7	3.23482E+18	13.39749773	5.1988E-05	0.999716493	5.94148E-05	2.599066889	1.1264E+20	5.34612E+22	0.000231884	0.0018	0.000456817	0.601075223	0.002270381
548	7	3.23482E+18	13.39749378	5.19879E-05	0.999716128	5.94148E-05	2.599066684	1.12639E+20	5.35454E+22	0.000232249	0.0018	0.000457535	0.602019987	0.00227395
549	7	3.23482E+18	13.39748984	5.19879E-05	0.999715763	5.94148E-05	2.599066479	1.12639E+20	5.36295E+22	0.000232614	0.0018	0.000458253	0.602964243	0.002277517
550	7	3.23482E+18	13.3974859	5.19879E-05	0.999715398	5.94147E-05	2.599066275	1.12639E+20	5.37135E+22	0.000232978	0.0018	0.00045897	0.603907992	0.002281081
551	7	3.23482E+18	13.39748196	5.19879E-05	0.999715034	5.94147E-05	2.59906607	1.12639E+20	5.37976E+22	0.000233343	0.0018	0.000459687	0.604851234	0.002284644
552	7	3.23482E+18	13.39747802	5.19879E-05	0.999714669	5.94147E-05	2.599065865	1.12639E+20	5.38815E+22	0.000233707	0.0018	0.000460403	0.605793969	0.002288205
553	7	3.23482E+18	13.39747408	5.19878E-05	0.999714305	5.94147E-05	2.599065661	1.12639E+20	5.39655E+22	0.000234071	0.0018	0.00046112	0.606736198	0.002291764
554	7	3.23482E+18	13.39747015	5.19878E-05	0.999713941	5.94147E-05	2.599065457	1.12639E+20	5.40493E+22	0.000234435	0.0018	0.000461835	0.607677921	0.002295321
555	7	3.23482E+18	13.39746621	5.19878E-05	0.999713577	5.94146E-05	2.599065253	1.12639E+20	5.41332E+22	0.000234799	0.0018	0.000462551	0.608619138	0.002298876
556	7	3.23482E+18	13.39746228	5.19878E-05	0.999713213	5.94146E-05	2.599065048	1.12639E+20	5.4217E+22	0.000235162	0.0018	0.000463265	0.60955985	0.002302429
557	7	3.23482E+18	13.39745836	5.19878E-05	0.99971285	5.94146E-05	2.599064844	1.12639E+20	5.43007E+22	0.000235526	0.0018	0.00046398	0.610500056	0.002305981
558	7	3.23482E+18	13.39745443	5.19878E-05	0.999712487	5.94146E-05	2.599064641	1.12639E+20	5.43844E+22	0.000235889	0.0018	0.000464694	0.611439758	0.00230953
559	7	3.23482E+18	13.39745051	5.19877E-05	0.999712123	5.94146E-05	2.599064437	1.12639E+20	5.44681E+22	0.000236252	0.0018	0.000465408	0.612378954	0.002313078
560	7	3.23482E+18	13.39744658	5.19877E-05	0.99971176	5.94145E-05	2.599064233	1.12639E+20	5.45517E+22	0.000236615	0.0018	0.000466121	0.613317646	0.002316623
561	7	3.23482E+18	13.39744266	5.19877E-05	0.999711398	5.94145E-05	2.59906403	1.12639E+20	5.46353E+22	0.000236977	0.0018	0.000466834	0.614255834	0.002320167
562	7	3.23482E+18	13.39743875	5.19877E-05	0.999711035	5.94145E-05	2.599063826	1.12639E+20	5.47188E+22	0.000237339	0.0018	0.000467547	0.615193519	0.002323709
563	7	3.23482E+18	13.39743483	5.19877E-05	0.999710673	5.94145E-05	2.599063623	1.12639E+20	5.48023E+22	0.000237702	0.0018	0.000468259	0.616130699	0.002327249
564	7	3.23482E+18	13.39743092	5.19876E-05	0.999710311	5.94144E-05	2.59906342	1.12639E+20	5.48857E+22	0.000238064	0.0018	0.000468971	0.617067376	0.002330787
565	7	3.23482E+18	13.39742701	5.19876E-05	0.999709949	5.94144E-05	2.599063217	1.12639E+20	5.49691E+22	0.000238425	0.0018	0.000469683	0.61800355	0.002334323
566	7	3.23482E+18	13.3974231	5.19876E-05	0.999709587	5.94144E-05	2.599063014	1.12639E+20	5.50525E+22	0.000238787	0.0018	0.000470394	0.618939222	0.002337857
567	7	3.23482E+18	13.39741919	5.19876E-05	0.999709225	5.94144E-05	2.599062811	1.12639E+20	5.51358E+22	0.000239148	0.0018	0.000471105	0.619874391	0.00234139
568	7	3.23482E+18	13.39741528	5.19876E-05	0.999708864	5.94144E-05	2.599062608	1.12639E+20	5.5219E+22	0.00023951	0.0018	0.000471815	0.620809057	0.00234492
569	7	3.23482E+18	13.39741138	5.19875E-05	0.999708503	5.94143E-05	2.599062405	1.12639E+20	5.53022E+22	0.000239871	0.0018	0.000472525	0.621743222	0.002348448
570	7	3.23482E+18	13.39740748	5.19875E-05	0.999708142	5.94143E-05	2.599062203	1.12639E+20	5.53854E+22	0.000240231	0.0018	0.000473234	0.622676885	0.002351975
571	7	3.23482E+18	13.39740358	5.19875E-05	0.999707781	5.94143E-05	2.599062	1.12639E+20	5.54685E+22	0.000240592	0.0018	0.000473944	0.623610047	0.0023555
572	7	3.23482E+18	13.39739968	5.19875E-05	0.999707421	5.94143E-05	2.599061798	1.12638E+20	5.55516E+22	0.000240952	0.0018	0.000474652	0.624542707	0.002359023
573	7	3.23482E+18	13.39739579	5.19875E-05	0.99970706	5.94143E-05	2.599061596	1.12638E+20	5.56346E+22	0.000241313	0.0018	0.000475361	0.625474867	0.002362544
574	7	3.23482E+18	13.3973919	5.19875E-05	0.9997067	5.94142E-05	2.599061393	1.12638E+20	5.57176E+22	0.000241673	0.0018	0.000476069	0.626406526	0.002366063
575	7	3.23482E+18	13.39738801	5.19874E-05	0.99970634	5.94142E-05	2.599061191	1.12638E+20	5.58006E+22	0.000242033	0.0018	0.000476777	0.627337684	0.00236958
576	7	3.23482E+18	13.39738412	5.19874E-05	0.99970598	5.94142E-05	2.59906099	1.12638E+20	5.58835E+22	0.000242392	0.0018	0.000477484	0.628268343	0.002373095
577	7	3.23482E+18	13.39738023	5.19874E-05	0.99970562	5.94142E-05	2.599060788	1.12638E+20	5.59664E+22	0.000242752	0.0018	0.000478191	0.629198502	0.002376609
578	7	3.23482E+18	13.39737635	5.19874E-05	0.999705261	5.94141E-05	2.599060586	1.12638E+20	5.60492E+22	0.000243111	0.0018	0.000478897	0.630128161	0.00238012
579	7	3.23482E+18	13.39737246	5.19874E-05	0.999704902	5.94141E-05	2.599060384	1.12638E+20	5.61319E+22	0.00024347	0.0018	0.000479604	0.631057321	0.00238363
580	7	3.23482E+18	13.39736858	5.19873E-05	0.999704543	5.94141E-05	2.599060183	1.12638E+20	5.62147E+22	0.000243829	0.0018	0.000480309	0.631985983	0.002387137
581	7	3.23482E+18	13.39736471	5.19873E-05	0.999704184	5.94141E-05	2.599059982	1.12638E+20	5.62974E+22	0.000244188	0.0018	0.000481015	0.632914145	0.002390643
582	7	3.23482E+18	13.39736083	5.19873E-05	0.999703825	5.94141E-05	2.59905978	1.12638E+20	5.638E+22	0.000244546	0.0018	0.00048172	0.633841809	0.002394147
583	7	3.23482E+18	13.39735696	5.19873E-05	0.999703466	5.9414E-05	2.599059579	1.12638E+20	5.64626E+22	0.000244905	0.0018	0.000482424	0.634768975	0.002397649
584	7	3.23482E+18	13.39735308	5.19873E-05	0.999703108	5.9414E-05	2.599059378	1.12638E+20	5.65451E+22	0.000245263	0.0018	0.000483129	0.635695643	0.00240115
585	7	3.23482E+18	13.39734921	5.19872E-05	0.99970275	5.9414E-05	2.599059177	1.12638E+20	5.66277E+22	0.000245621	0.0018	0.000483833	0.636621814	0.002404648
586	7	3.23482E+18	13.39734535	5.19872E-05	0.999702392	5.9414E-05	2.599058976	1.12638E+20	5.67101E+22	0.000245978	0.0018	0.000484536	0.637547487	0.002408144
587	7	3.23482E+18	13.39734148	5.19872E-05	0.999702034	5.9414E-05	2.599058775	1.12638E+20	5.67925E+22	0.000246336	0.0018	0.000485239	0.638472663	0.002411639
588	7	3.23482E+18	13.39733762	5.19872E-05	0.999701677	5.94139E-05	2.599058575	1.12638E+20	5.68749E+22	0.000246693	0.0018	0.000485942	0.639397343	0.002415132
589	7	3.23482E+18	13.39733375	5.19872E-05	0.999701319	5.94139E-05	2.599058374	1.12638E+20	5.69573E+22	0.000247051	0.0018	0.000486644	0.640321526	0.002418622
590	7	3.23482E+18	13.39732989	5.19872E-05	0.999700962	5.94139E-05	2.599058174	1.12638E+20	5.70395E+22	0.000247408	0.0018	0.000487346	0.641245212	0.002422111
591	7	3.23482E+18	13.39732604	5.19871E-05	0.999700605	5.94139E-05	2.599057974	1.12638E+20	5.71218E+22	0.000247764	0.0018	0.000488048	0.642168403	0.002425598
592	7	3.23482E+18	13.39732218	5.19871E-05	0.999700249	5.94138E-05	2.599057773	1.12638E+20	5.7204E+22	0.000248121	0.0018	0.000488749	0.643091098	0.002429084
593	7	3.23482E+18	13.39731833	5.19871E-05	0.999699892	5.94138E-05	2.599057573	1.12638E+20	5.72861E+22	0.000248477	0.0018	0.00048945	0.644013297	0.002432567
594	7	3.23482E+18	13.39731448	5.19871E-05	0.999699536	5.94138E-05	2.599057373	1.12638E+20	5.73683E+22	0.000248834	0.0018	0.000490151	0.644935002	0.002436048
595	7	3.23482E+18	13.39731063	5.19871E-05	0.999699179	5.94138E-05	2.599057173	1.12638E+20	5.74503E+22	0.00024919	0.0018	0.000490851	0.645856211	0.002439528
596	7	3.23482E+18	13.39730678	5.1987E-05	0.999698823	5.94138E-05	2.599056974	1.12637E+20	5.75324E+22	0.000249546	0.0018	0.00049155	0.646776926	0.002443006
597	7	3.23482E+18	13.39730293	5.1987E-05	0.999698467	5.94137E-05	2.599056774	1.12637E+20	5.76143E+22	0.000249901	0.0018	0.00049225	0.647697147	0.002446482
598	7	3.23482E+18	13.39729909	5.1987E-05	0.999698112	5.94137E-05	2.599056574	1.12637E+20	5.76963E+22	0.000250257	0.0018	0.000492949	0.648616873	0.002449956

599	7	3.23482E+18	13.39729525	5.1987E-05	0.999697756	5.94137E-05	2.599056375	1.12637E+20	5.77782E+22	0.000250612	0.0018	0.000493647	0.649536106	0.002453428
600	7	3.23482E+18	13.39729141	5.1987E-05	0.999697401	5.94137E-05	2.599056175	1.12637E+20	5.786E+22	0.000250967	0.0018	0.000494346	0.650454845	0.002456898
601	7	3.23482E+18	13.39728757	5.19869E-05	0.999697046	5.94137E-05	2.599055976	1.12637E+20	5.79418E+22	0.000251322	0.0018	0.000495044	0.651373091	0.002460366
602	7	3.23482E+18	13.39728374	5.19869E-05	0.999696691	5.94136E-05	2.599055777	1.12637E+20	5.80236E+22	0.000251677	0.0018	0.000495741	0.652290844	0.002463833
603	7	3.23482E+18	13.3972799	5.19869E-05	0.999696336	5.94136E-05	2.599055578	1.12637E+20	5.81053E+22	0.000252031	0.0018	0.000496438	0.653208104	0.002467298
604	7	3.23482E+18	13.39727607	5.19869E-05	0.999695982	5.94136E-05	2.599055379	1.12637E+20	5.8187E+22	0.000252386	0.0018	0.000497135	0.654124872	0.00247076
605	7	3.23482E+18	13.39727224	5.19869E-05	0.999695628	5.94136E-05	2.59905518	1.12637E+20	5.82686E+22	0.00025274	0.0018	0.000497831	0.655041147	0.002474221
606	7	3.23482E+18	13.39726842	5.19869E-05	0.999695273	5.94136E-05	2.599054981	1.12637E+20	5.83502E+22	0.000253094	0.0018	0.000498527	0.655956931	0.002477681
607	7	3.23482E+18	13.39726459	5.19868E-05	0.999694919	5.94135E-05	2.599054783	1.12637E+20	5.84318E+22	0.000253448	0.0018	0.000499223	0.656872223	0.002481138
608	7	3.23482E+18	13.39726077	5.19868E-05	0.999694566	5.94135E-05	2.599054584	1.12637E+20	5.85133E+22	0.000253801	0.0018	0.000499918	0.657787024	0.002484593
609	7	3.23482E+18	13.39725695	5.19868E-05	0.999694212	5.94135E-05	2.599054386	1.12637E+20	5.85947E+22	0.000254155	0.0018	0.000500613	0.658701333	0.002488047
610	7	3.23482E+18	13.39725313	5.19868E-05	0.999693859	5.94135E-05	2.599054188	1.12637E+20	5.86761E+22	0.000254508	0.0018	0.000501308	0.659615152	0.002491498
611	7	3.23482E+18	13.39724931	5.19868E-05	0.999693505	5.94134E-05	2.599053989	1.12637E+20	5.87575E+22	0.000254861	0.0018	0.000502002	0.66052848	0.002494948
612	7	3.23482E+18	13.3972455	5.19867E-05	0.999693152	5.94134E-05	2.599053791	1.12637E+20	5.88389E+22	0.000255214	0.0018	0.000502695	0.661441317	0.002498396
613	7	3.23482E+18	13.39724169	5.19867E-05	0.9996928	5.94134E-05	2.599053593	1.12637E+20	5.89201E+22	0.000255566	0.0018	0.000503389	0.662353665	0.002501842
614	7	3.23482E+18	13.39723788	5.19867E-05	0.999692447	5.94134E-05	2.599053395	1.12637E+20	5.90014E+22	0.000255919	0.0018	0.000504082	0.663265523	0.002505287
615	7	3.23482E+18	13.39723407	5.19867E-05	0.999692095	5.94134E-05	2.599053198	1.12637E+20	5.90826E+22	0.000256271	0.0018	0.000504774	0.664176891	0.002508729
616	7	3.23482E+18	13.39723026	5.19867E-05	0.999691742	5.94133E-05	2.599053	1.12637E+20	5.91637E+22	0.000256623	0.0018	0.000505467	0.66508777	0.00251217
617	7	3.23482E+18	13.39722646	5.19867E-05	0.99969139	5.94133E-05	2.599052802	1.12637E+20	5.92449E+22	0.000256975	0.0018	0.000506159	0.665998161	0.002515608
618	7	3.23482E+18	13.39722265	5.19866E-05	0.999691038	5.94133E-05	2.599052605	1.12637E+20	5.93259E+22	0.000257327	0.0018	0.00050685	0.666908062	0.002519045
619	7	3.23482E+18	13.39721885	5.19866E-05	0.999690687	5.94133E-05	2.599052408	1.12637E+20	5.9407E+22	0.000257678	0.0018	0.000507541	0.667817475	0.00252248
620	7	3.23482E+18	13.39721505	5.19866E-05	0.999690335	5.94133E-05	2.59905221	1.12636E+20	5.94879E+22	0.00025803	0.0018	0.000508232	0.6687264	0.002525913
621	7	3.23482E+18	13.39721126	5.19866E-05	0.999689984	5.94132E-05	2.599052013	1.12636E+20	5.95689E+22	0.000258381	0.0018	0.000508922	0.669634837	0.002529345
622	7	3.23482E+18	13.39720746	5.19866E-05	0.999689633	5.94132E-05	2.599051816	1.12636E+20	5.96498E+22	0.000258732	0.0018	0.000509613	0.670542786	0.002532774
623	7	3.23482E+18	13.39720367	5.19865E-05	0.999689282	5.94132E-05	2.599051619	1.12636E+20	5.97306E+22	0.000259083	0.0018	0.000510302	0.671450248	0.002536202
624	7	3.23482E+18	13.39719988	5.19865E-05	0.999688931	5.94132E-05	2.599051422	1.12636E+20	5.98114E+22	0.000259433	0.0018	0.000510991	0.672357223	0.002539628
625	7	3.23482E+18	13.39719609	5.19865E-05	0.99968858	5.94132E-05	2.599051226	1.12636E+20	5.98922E+22	0.000259784	0.0018	0.00051168	0.673263711	0.002543052
626	7	3.23482E+18	13.39719231	5.19865E-05	0.99968823	5.94131E-05	2.599051029	1.12636E+20	5.99729E+22	0.000260134	0.0018	0.000512369	0.674169712	0.002546474
627	7	3.23482E+18	13.39718852	5.19865E-05	0.99968788	5.94131E-05	2.599050833	1.12636E+20	6.00536E+22	0.000260484	0.0018	0.000513057	0.675075227	0.002549894
628	7	3.23482E+18	13.39718474	5.19865E-05	0.99968753	5.94131E-05	2.599050636	1.12636E+20	6.01343E+22	0.000260834	0.0018	0.000513745	0.675980256	0.002553313
629	7	3.23482E+18	13.39718096	5.19864E-05	0.99968718	5.94131E-05	2.59905044	1.12636E+20	6.02149E+22	0.000261183	0.0018	0.000514432	0.676884799	0.002556729
630	7	3.23482E+18	13.39717718	5.19864E-05	0.99968683	5.9413E-05	2.599050244	1.12636E+20	6.02954E+22	0.000261533	0.0018	0.00051512	0.677788857	0.002560144
631	7	3.23482E+18	13.3971734	5.19864E-05	0.999686481	5.9413E-05	2.599050047	1.12636E+20	6.03759E+22	0.000261882	0.0018	0.000515806	0.678692429	0.002563557
632	7	3.23482E+18	13.39716963	5.19864E-05	0.999686132	5.9413E-05	2.599049851	1.12636E+20	6.04564E+22	0.000262231	0.0018	0.000516493	0.679595517	0.002566968
633	7	3.23482E+18	13.39716586	5.19864E-05	0.999685782	5.9413E-05	2.599049656	1.12636E+20	6.05368E+22	0.00026258	0.0018	0.000517179	0.680498119	0.002570377
634	7	3.23482E+18	13.39716209	5.19863E-05	0.999685434	5.9413E-05	2.59904946	1.12636E+20	6.06172E+22	0.000262929	0.0018	0.000517864	0.681400238	0.002573785
635	7	3.23482E+18	13.39715832	5.19863E-05	0.999685085	5.94129E-05	2.599049264	1.12636E+20	6.06975E+22	0.000263277	0.0018	0.000518549	0.682301872	0.002577191
636	7	3.23482E+18	13.39715455	5.19863E-05	0.999684736	5.94129E-05	2.599049069	1.12636E+20	6.07778E+22	0.000263626	0.0018	0.000519234	0.683203022	0.002580594
637	7	3.23482E+18	13.39715079	5.19863E-05	0.999684388	5.94129E-05	2.599048873	1.12636E+20	6.08581E+22	0.000263974	0.0018	0.000519919	0.684103688	0.002583996
638	7	3.23482E+18	13.39714703	5.19863E-05	0.99968404	5.94129E-05	2.599048678	1.12636E+20	6.09383E+22	0.000264322	0.0018	0.000520603	0.685003871	0.002587397
639	7	3.23482E+18	13.39714327	5.19863E-05	0.999683692	5.94129E-05	2.599048482	1.12636E+20	6.10185E+22	0.00026467	0.0018	0.000521287	0.685903571	0.002590795
640	7	3.23482E+18	13.39713951	5.19862E-05	0.999683344	5.94128E-05	2.599048287	1.12636E+20	6.10986E+22	0.000265017	0.0018	0.00052197	0.686802788	0.002594191
641	7	3.23482E+18	13.39713575	5.19862E-05	0.999682996	5.94128E-05	2.599048092	1.12636E+20	6.11787E+22	0.000265365	0.0018	0.000522653	0.687701522	0.002597586
642	7	3.23482E+18	13.397132	5.19862E-05	0.999682649	5.94128E-05	2.599047897	1.12636E+20	6.12587E+22	0.000265712	0.0018	0.000523336	0.688599775	0.002600979
643	7	3.23482E+18	13.39712824	5.19862E-05	0.999682302	5.94128E-05	2.599047702	1.12636E+20	6.13387E+22	0.000266059	0.0018	0.000524018	0.689497544	0.00260437
644	7	3.23482E+18	13.39712449	5.19862E-05	0.999681955	5.94128E-05	2.599047508	1.12636E+20	6.14187E+22	0.000266406	0.0018	0.0005247	0.690394833	0.002607759
645	7	3.23482E+18	13.39712075	5.19861E-05	0.999681608	5.94127E-05	2.599047313	1.12636E+20	6.14986E+22	0.000266753	0.0018	0.000525382	0.691291639	0.002611147
646	7	3.23482E+18	13.397117	5.19861E-05	0.999681261	5.94127E-05	2.599047118	1.12635E+20	6.15785E+22	0.000267099	0.0018	0.000526063	0.692187964	0.002614532
647	7	3.23482E+18	13.39711326	5.19861E-05	0.999680915	5.94127E-05	2.599046924	1.12635E+20	6.16583E+22	0.000267446	0.0018	0.000526744	0.693083809	0.002617916
648	7	3.23482E+18	13.39710951	5.19861E-05	0.999680568	5.94127E-05	2.59904673	1.12635E+20	6.17381E+22	0.000267792	0.0018	0.000527424	0.693979172	0.002621298
649	7	3.23482E+18	13.39710577	5.19861E-05	0.999680222	5.94127E-05	2.599046535	1.12635E+20	6.18178E+22	0.000268138	0.0018	0.000528104	0.694874055	0.002624678
650	7	3.23482E+18	13.39710203	5.19861E-05	0.999679876	5.94126E-05	2.599046341	1.12635E+20	6.18975E+22	0.000268484	0.0018	0.000528784	0.695768458	0.002628057
651	7	3.23482E+18	13.3970983	5.1986E-05	0.99967953	5.94126E-05	2.599046147	1.12635E+20	6.19772E+22	0.000268829	0.0018	0.000529463	0.69666238	0.002631433
652	7	3.23482E+18	13.39709456	5.1986E-05	0.999679185	5.94126E-05	2.599045953	1.12635E+20	6.20568E+22	0.000269175	0.0018	0.000530142	0.697555823	0.002634808
653	7	3.23482E+18	13.39709083	5.1986E-05	0.999678839	5.94126E-05	2.599045759	1.12635E+20	6.21364E+22	0.00026952	0.0018	0.000530821	0.698448787	0.002638181
654	7	3.23482E+18	13.3970871	5.1986E-05	0.999678494	5.94126E-05	2.599045566	1.12635E+20	6.22159E+22	0.000269865	0.0018	0.000531499	0.699341271	0.002641552
655	7	3.23482E+18	13.39708337	5.1986E-05	0.999678149	5.94125E-05	2.599045372	1.12635E+20	6.22954E+22	0.00027021	0.0018	0.000532177	0.700233276	0.002644921
656	7	3.23482E+18	13.39707965	5.19859E-05	0.999677804	5.94125E-05	2.599045179	1.12635E+20	6.23748E+22	0.000270554	0.0018	0.000532855	0.701124803	0.002648289
657	7	3.23482E+18	13.39707592	5.19859E-05	0.99967746	5.94125E-05	2.599044985	1.12635E+20	6.24543E+22	0.000270899	0.0018	0.000533532	0.702015851	0.002651654
658	7	3.23482E+18	13.3970722	5.19859E-05	0.999677115	5.94125E-05	2.599044792	1.12635E+20	6.25336E+22	0.000271243	0.0018	0.000534209	0.702906421	0.002655018
659	7	3.23482E+18	13.39706848	5.19859E-05	0.999676771	5.94125E-05	2.599044599	1.12635E+20	6.26129E+22	0.000271587	0.0018	0.000534885	0.703796513	0.00265838
660	7	3.23482E+18	13.39706476	5.19859E-05	0.999676427	5.94124E-05	2.599044406	1.12635E+20	6.26922E+22	0.000271931	0.0018	0.000535561	0.704686128	0.00266174
661	7	3.23482E+18	13.39706104	5.19859E-05	0.999676083	5.94124E-05	2.599044213	1.12635E+20	6.27714E+22	0.000272275	0.0018	0.000536237	0.705575265	0.002665099
662	7	3.23482E+18	13.39705733	5.19858E-05	0.999675739	5.94124E-05	2.59904402	1.12635E+20	6.28506E+22	0.000272619	0.0018	0.000536913	0.706463925	0.002668456
663	7	3.23482E+18	13.39705362	5.19858E-05	0.999675396	5.94124E-05	2.599043827	1.12635E+20	6.29298E+22	0.000272962	0.0018	0.000537588	0.707352108	0.00267181
664	7	3.23482E+18	13.39704991	5.19858E-05	0.999675052	5.94123E-05	2.599043634	1.12635E+20	6.30089E+22	0.000273305	0.0018	0.000538262	0.708239814	0.002675163
665	7	3.23482E+18	13.3970462	5.19858E-05	0.999674709	5.94123E-05	2.599043442	1.12635E+20	6.3088E+22	0.000273648	0.0018	0.000538937	0.709127045	0.002678515
666	7	3.23482E+18	13.39704249	5.19858E-05	0.999674366	5.94123E-05	2.599043249	1.12635E+20	6.3167E+22	0.000273991	0.0018	0.00053961	0.710013799	0.002681864
667	7	3.23482E+18	13.39703879	5.19858E-05	0.999674023	5.94123E-05	2.599043057	1.12635E+20	6.3246E+22	0.000274334	0.0018	0.000540284	0.710900077	0.002685212
668	7	3.23482E+18	13.39703508	5.19857E-05	0.99967368	5.94123E-05	2.599042864	1.12635E+20	6.33249E+22	0.000274676	0.0018	0.000540957	0.71178588	0.002688558
669	7	3.23482E+18	13.39703138	5.19857E-05	0.999673338	5.94122E-05	2.599042672	1.12635E+20	6.34038E+22	0.000275019	0.0018	0.00054163	0.712671207	0.002691902
670	7	3.23482E+18	13.39702768	5.19857E-05	0.999672996	5.94122E-05	2.59904248	1.12634E+20	6.34827E+22	0.000275361	0.0018	0.000542303	0.713556059	0.002695244
671	7	3.23482E+18	13.39702399	5.19857E-05	0.999672654	5.94122E-05	2.599042288	1.12634E+20	6.35615E+22	0.000275703	0.0018	0.000542975	0.714440437	0.002698584
672	7	3.23482E+18	13.39702029	5.19857E-05	0.999672312	5.94122E-05	2.599042096	1.12634E+20	6.36403E+22	0.000276044	0.0018	0.000543646	0.71532434	0.002701923
673	7	3.23482E+18	13.3970166	5.19856E-05	0.99967197	5.94122E-05	2.599041905	1.12634E+20	6.3719E+22	0.000276386	0.0018	0.000544318	0.716207769	0.00270526
674	7	3.23482E+18	13.39701291	5.19856E-05	0.999671628	5.94121E-05	2.599041713	1.12634E+20	6.37977E+22	0.000276727	0.0018	0.000544989	0.717090724	0.002708595
675	7	3.23482E+18	13.39700922	5.19856E-05	0.999671287	5.94121E-05	2.599041521	1.12634E+20	6.38763E+22	0.000277069	0.0018	0.00054566	0.717973205	0.002711928
676	7	3.23482E+18	13.39700553	5.19856E-05	0.999670946	5.94121E-05	2.59904133	1.12634E+20	6.39549E+22	0.00027741	0.0018	0.00054633	0.718855212	0.00271526
677	7	3.23482E+18	13.39700185	5.19856E-05	0.999670605	5.94121E-05	2.599041138	1.12634E+20	6.40335E+22	0.00027775	0.0018	0.000547	0.719736746	0.00271859
678	7	3.23482E+18	13.39699817	5.19856E-05	0.999670264	5.94121E-05	2.599040947	1.12634E+20	6.4112E+22	0.000278091	0.0018	0.00054767	0.720617808	0.002721918
679	7	3.23482E+18	13.39699449	5.19855E-05	0.999669923	5.9412E-05	2.599040756	1.12634E+20	6.41905E+22	0.000278432	0.0018	0.000548339	0.721498396	0.002725244
680	7	3.23482E+18	13.39699081	5.19855E-05	0.999669583	5.9412E-05	2.599040565	1.12634E+20	6.42689E+22	0.000278772	0.0018	0.000549008	0.722378512	0.002728568
681	7	3.23482E+18	13.39698713	5.19855E-05	0.999669243	5.9412E-05	2.599040374	1.12634E+20	6.43473E+22	0.000279112	0.0018	0.000549676	0.723258156	0.002731891
682	7	3.23482E+18	13.39698345	5.19855E-05	0.999668902	5.9412E-05	2.599040183	1.12634E+20	6.44257E+22	0.000279452	0.0018	0.000550344	0.724137328	0.002735212
683	7	3.23482E+18	13.39697978	5.19855E-05	0.999668563	5.9412E-05	2.599039992	1.12634E+20	6.4504E+22	0.000279792	0.0018	0.000551012	0.725016029	0.002738531
684	7	3.23482E+18	13.39697611	5.19855E-05	0.999668223	5.94119E-05	2.599039802	1.12634E+20	6.45823E+22	0.000280131	0.0018	0.00055168	0.725894257	0.002741848
685	7	3.23482E+18	13.39697244	5.19854E-05	0.999667883	5.94119E-05	2.599039611	1.12634E+20	6.46605E+22	0.000280471	0.0018	0.000552347	0.726772015	0.002745163
686	7	3.23482E+18	13.39696877	5.19854E-05	0.999667544	5.94119E-05	2.599039421	1.12634E+20	6.47387E+22	0.00028081	0.0018	0.000553013	0.727649302	0.002748477
687	7	3.23482E+18	13.39696511	5.19854E-05	0.999667205	5.94119E-05	2.59903923	1.12634E+20	6.48168E+22	0.000281149	0.0018	0.00055368	0.728526118	0.002751789
688	7	3.23482E+18	13.39696144	5.19854E-05	0.999666866	5.94119E-05	2.59903904	1.12634E+20	6.48949E+22	0.000281488	0.0018	0.000554346	0.729402463	0.002755099
689	7	3.23482E+18	13.39695778	5.19854E-05	0.999666527	5.94118E-05	2.59903885	1.12634E+20	6.4973E+22	0.000281827	0.0018	0.000555012	0.730278339	0.002758407
690	7	3.23482E+18	13.39695412	5.19853E-05	0.999666188	5.94118E-05	2.59903866	1.12634E+20	6.5051E+22	0.000282165	0.0018	0.000555677	0.731153745	0.002761714
691	7	3.23482E+18	13.39695047	5.19853E-05	0.99966585	5.94118E-05	2.59903847	1.12634E+20	6.5129E+22	0.000282503	0.0018	0.000556342	0.732028681	0.002765019
692	7	3.23482E+18	13.39694681	5.19853E-05	0.999665511	5.94118E-05	2.59903828	1.12634E+20	6.52069E+22	0.000282842	0.0018	0.000557006	0.732903147	0.002768322
693	7	3.23482E+18	13.39694316	5.19853E-05	0.999665173	5.94118E-05	2.59903809	1.12634E+20	6.52848E+22	0.000283179	0.0018	0.000557671	0.733777145	0.002771623
694	7	3.23482E+18	13.3969395	5.19853E-05	0.999664835	5.94117E-05	2.599037901	1.12634E+20	6.53627E+22	0.000283517	0.0018	0.000558335	0.734650673	0.002774923
695	7	3.23482E+18	13.39693585	5.19853E-05	0.999664497	5.94117E-05	2.599037711	1.12634E+20	6.54405E+22	0.000283855	0.0018	0.000558998	0.735523733	0.00277822
696	7	3.23482E+18	13.39693221	5.19852E-05	0.99966416	5.94117E-05	2.599037522	1.12633E+20	6.55183E+22	0.000284192	0.0018	0.000559661	0.736396325	0.002781516
697	7	3.23482E+18	13.39692856	5.19852E-05	0.999663822	5.94117E-05	2.599037332	1.12633E+20	6.5596E+22	0.00028453	0.0018	0.000560324	0.737268448	0.00278481
698	7	3.23482E+18	13.39692492	5.19852E-05	0.999663485	5.94117E-05	2.599037143	1.12633E+20	6.56737E+22	0.000284867	0.0018	0.000560986	0.738140104	0.002788103
699	7	3.23482E+18	13.39692127	5.19852E-05	0.999663148	5.94116E-05	2.599036954	1.12633E+20	6.57513E+22	0.000285203	0.0018	0.000561649	0.739011292	0.002791393
700	7	3.23482E+18	13.39691763	5.19852E-05	0.999662811	5.94116E-05	2.599036765	1.12633E+20	6.5829E+22	0.00028554	0.0018	0.00056231	0.739882013	0.002794682
701	7	3.23482E+18	13.396914	5.19852E-05	0.999662475	5.94116E-05	2.599036576	1.12633E+20	6.59065E+22	0.000285877	0.0018	0.000562972	0.740752266	0.002797969
702	7	3.23482E+18	13.39691036	5.19851E-05	0.999662138	5.94116E-05	2.599036387	1.12633E+20	6.5984E+22	0.000286213	0.0018	0.000563633	0.741622053	0.002801255
703	7	3.23482E+18	13.39690673	5.19851E-05	0.999661802	5.94116E-05	2.599036198	1.12633E+20	6.60615E+22	0.000286549	0.0018	0.000564293	0.742491374	0.002804538
704	7	3.23482E+18	13.39690309	5.19851E-05	0.999661466	5.94115E-05	2.59903601	1.12633E+20	6.6139E+22	0.000286885	0.0018	0.000564954	0.743360227	0.00280782
705	7	3.23482E+18	13.39689946	5.19851E-05	0.99966113	5.94115E-05	2.599035821	1.12633E+20	6.62164E+22	0.000287221	0.0018	0.000565614	0.744228615	0.0028111
706	7	3.23482E+18	13.39689583	5.19851E-05	0.999660794	5.94115E-05	2.599035633	1.12633E+20	6.62937E+22	0.000287557	0.0018	0.000566273	0.745096537	0.002814379
707	7	3.23482E+18	13.39689221	5.1985E-05	0.999660458	5.94115E-05	2.599035445	1.12633E+20	6.63711E+22	0.000287892	0.0018	0.000566933	0.745963994	0.002817655
708	7	3.23482E+18	13.39688858	5.1985E-05	0.999660123	5.94115E-05	2.599035256	1.12633E+20	6.64483E+22	0.000288227	0.0018	0.000567592	0.746830985	0.00282093
709	7	3.23482E+18	13.39688496	5.1985E-05	0.999659788	5.94114E-05	2.599035068	1.12633E+20	6.65256E+22	0.000288563	0.0018	0.00056825	0.747697511	0.002824203
710	7	3.23482E+18	13.39688134	5.1985E-05	0.999659452	5.94114E-05	2.59903488	1.12633E+20	6.66028E+22	0.000288897	0.0018	0.000568908	0.748563572	0.002827474
711	7	3.23482E+18	13.39687772	5.1985E-05	0.999659118	5.94114E-05	2.599034692	1.12633E+20	6.66799E+22	0.000289232	0.0018	0.000569566	0.749429169	0.002830744
712	7	3.23482E+18	13.3968741	5.1985E-05	0.999658783	5.94114E-05	2.599034504	1.12633E+20	6.6757E+22	0.000289567	0.0018	0.000570224	0.750294301	0.002834012
713	7	3.23482E+18	13.39687049	5.19849E-05	0.999658448	5.94114E-05	2.599034317	1.12633E+20	6.68341E+22	0.000289901	0.0018	0.000570881	0.75115897	0.002837278
714	7	3.23482E+18	13.39686688	5.19849E-05	0.999658114	5.94113E-05	2.599034129	1.12633E+20	6.69111E+22	0.000290235	0.0018	0.000571538	0.752023174	0.002840542
715	7	3.23482E+18	13.39686327	5.19849E-05	0.99965778	5.94113E-05	2.599033941	1.12633E+20	6.69881E+22	0.000290569	0.0018	0.000572194	0.752886915	0.002843804
716	7	3.23482E+18	13.39685966	5.19849E-05	0.999657446	5.94113E-05	2.599033754	1.12633E+20	6.70651E+22	0.000290903	0.0018	0.00057285	0.753750193	0.002847065
717	7	3.23482E+18	13.39685605	5.19849E-05	0.999657112	5.94113E-05	2.599033567	1.12633E+20	6.7142E+22	0.000291237	0.0018	0.000573506	0.754613008	0.002850324
718	7	3.23482E+18	13.39685244	5.19849E-05	0.999656778	5.94113E-05	2.599033379	1.12633E+20	6.72188E+22	0.00029157	0.0018	0.000574161	0.75547536	0.002853582
719	7	3.23482E+18	13.39684884	5.19848E-05	0.999656445	5.94112E-05	2.599033192	1.12633E+20	6.72957E+22	0.000291904	0.0018	0.000574816	0.756337249	0.002856837
720	7	3.23482E+18	13.39684524	5.19848E-05	0.999656111	5.94112E-05	2.599033005	1.12633E+20	6.73725E+22	0.000292237	0.0018	0.000575471	0.757198677	0.002860091
721	7	3.23482E+18	13.39684164	5.19848E-05	0.999655778	5.94112E-05	2.599032818	1.12633E+20	6.74492E+22	0.00029257	0.0018	0.000576125	0.758059642	0.002863343
722	7	3.23482E+18	13.39683804	5.19848E-05	0.999655445	5.94112E-05	2.599032631	1.12632E+20	6.75259E+22	0.000292903	0.0018	0.000576779	0.758920145	0.002866593
723	7	3.23482E+18	13.39683445	5.19848E-05	0.999655113	5.94112E-05	2.599032445	1.12632E+20	6.76026E+22	0.000293235	0.0018	0.000577433	0.759780187	0.002869842
724	7	3.23482E+18	13.39683085	5.19848E-05	0.99965478	5.94111E-05	2.599032258	1.12632E+20	6.76792E+22	0.000293568	0.0018	0.000578086	0.760639767	0.002873089
725	7	3.23482E+18	13.39682726	5.19847E-05	0.999654448	5.94111E-05	2.599032071	1.12632E+20	6.77558E+22	0.0002939	0.0018	0.000578739	0.761498887	0.002876334
726	7	3.23482E+18	13.39682367	5.19847E-05	0.999654115	5.94111E-05	2.599031885	1.12632E+20	6.78323E+22	0.000294232	0.0018	0.000579392	0.762357546	0.002879577

727	7	3.23482E+18	13.39682008	5.19847E-05	0.999653783	5.94111E-05	2.599031699	1.12632E+20	6.79088E+22	0.000294564	0.0018	0.000580044	0.763215744	0.002882819
728	7	3.23482E+18	13.39681649	5.19847E-05	0.999653451	5.94111E-05	2.599031512	1.12632E+20	6.79853E+22	0.000294896	0.0018	0.000580696	0.764073482	0.002886058
729	7	3.23482E+18	13.39681291	5.19847E-05	0.99965312	5.9411E-05	2.599031326	1.12632E+20	6.80617E+22	0.000295227	0.0018	0.000581347	0.76493076	0.002889296
730	7	3.23482E+18	13.39680933	5.19846E-05	0.999652788	5.9411E-05	2.59903114	1.12632E+20	6.81381E+22	0.000295559	0.0018	0.000581999	0.765787578	0.002892533
731	7	3.23482E+18	13.39680575	5.19846E-05	0.999652457	5.9411E-05	2.599030954	1.12632E+20	6.82144E+22	0.00029589	0.0018	0.000582649	0.766643937	0.002895767
732	7	3.23482E+18	13.39680217	5.19846E-05	0.999652126	5.9411E-05	2.599030768	1.12632E+20	6.82907E+22	0.000296221	0.0018	0.0005833	0.767499836	0.002899
733	7	3.23482E+18	13.39679859	5.19846E-05	0.999651795	5.9411E-05	2.599030583	1.12632E+20	6.83669E+22	0.000296552	0.0018	0.00058395	0.768355277	0.002902232
734	7	3.23482E+18	13.39679502	5.19846E-05	0.999651464	5.94109E-05	2.599030397	1.12632E+20	6.84432E+22	0.000296882	0.0018	0.0005846	0.769210258	0.002905461
735	7	3.23482E+18	13.39679144	5.19846E-05	0.999651133	5.94109E-05	2.599030211	1.12632E+20	6.85193E+22	0.000297213	0.0018	0.000585249	0.770064781	0.002908689
736	7	3.23482E+18	13.39678787	5.19845E-05	0.999650803	5.94109E-05	2.599030026	1.12632E+20	6.85955E+22	0.000297543	0.0018	0.000585898	0.770918846	0.002911915
737	7	3.23482E+18	13.3967843	5.19845E-05	0.999650472	5.94109E-05	2.599029841	1.12632E+20	6.86716E+22	0.000297873	0.0018	0.000586547	0.771772453	0.002915139
738	7	3.23482E+18	13.39678074	5.19845E-05	0.999650142	5.94109E-05	2.599029655	1.12632E+20	6.87476E+22	0.000298203	0.0018	0.000587195	0.772625602	0.002918361
739	7	3.23482E+18	13.39677717	5.19845E-05	0.999649812	5.94108E-05	2.59902947	1.12632E+20	6.88236E+22	0.000298533	0.0018	0.000587844	0.773478294	0.002921582
740	7	3.23482E+18	13.39677361	5.19845E-05	0.999649482	5.94108E-05	2.599029285	1.12632E+20	6.88996E+22	0.000298863	0.0018	0.000588491	0.774330528	0.002924801
741	7	3.23482E+18	13.39677005	5.19845E-05	0.999649153	5.94108E-05	2.5990291	1.12632E+20	6.89755E+22	0.000299192	0.0018	0.000589139	0.775182305	0.002928019
742	7	3.23482E+18	13.39676649	5.19844E-05	0.999648823	5.94108E-05	2.599028915	1.12632E+20	6.90514E+22	0.000299521	0.0018	0.000589786	0.776033626	0.002931234
743	7	3.23482E+18	13.39676293	5.19844E-05	0.999648494	5.94108E-05	2.599028731	1.12632E+20	6.91273E+22	0.00029985	0.0018	0.000590432	0.77688449	0.002934448
744	7	3.23482E+18	13.39675937	5.19844E-05	0.999648165	5.94108E-05	2.599028546	1.12632E+20	6.92031E+22	0.000300179	0.0018	0.000591079	0.777734897	0.00293766
745	7	3.23482E+18	13.39675582	5.19844E-05	0.999647836	5.94107E-05	2.599028361	1.12632E+20	6.92789E+22	0.000300508	0.0018	0.000591724	0.778584849	0.002940871
746	7	3.23482E+18	13.39675227	5.19844E-05	0.999647507	5.94107E-05	2.599028177	1.12632E+20	6.93546E+22	0.000300837	0.0018	0.00059237	0.779434345	0.002944079
747	7	3.23482E+18	13.39674872	5.19844E-05	0.999647179	5.94107E-05	2.599027992	1.12632E+20	6.94303E+22	0.000301165	0.0018	0.000593015	0.780283385	0.002947286
748	7	3.23482E+18	13.39674517	5.19843E-05	0.999646851	5.94107E-05	2.599027808	1.12631E+20	6.95059E+22	0.000301493	0.0018	0.00059366	0.78113197	0.002950492
749	7	3.23482E+18	13.39674162	5.19843E-05	0.999646522	5.94107E-05	2.599027624	1.12631E+20	6.95815E+22	0.000301821	0.0018	0.000594305	0.7819801	0.002953695
750	7	3.23482E+18	13.39673808	5.19843E-05	0.999646194	5.94106E-05	2.59902744	1.12631E+20	6.96571E+22	0.000302149	0.0018	0.000594949	0.782827776	0.002956897
751	7	3.23482E+18	13.39673454	5.19843E-05	0.999645866	5.94106E-05	2.599027256	1.12631E+20	6.97326E+22	0.000302477	0.0018	0.000595593	0.783674996	0.002960097
752	7	3.23482E+18	13.396731	5.19843E-05	0.999645539	5.94106E-05	2.599027072	1.12631E+20	6.98081E+22	0.000302804	0.0018	0.000596237	0.784521763	0.002963296
753	7	3.23482E+18	13.39672746	5.19843E-05	0.999645211	5.94106E-05	2.599026888	1.12631E+20	6.98836E+22	0.000303132	0.0018	0.00059688	0.785368075	0.002966492
754	7	3.23482E+18	13.39672392	5.19842E-05	0.999644884	5.94106E-05	2.599026705	1.12631E+20	6.9959E+22	0.000303459	0.0018	0.000597523	0.786213934	0.002969687
755	7	3.23482E+18	13.39672038	5.19842E-05	0.999644557	5.94105E-05	2.599026521	1.12631E+20	7.00343E+22	0.000303786	0.0018	0.000598165	0.787059339	0.002972881
756	7	3.23482E+18	13.39671685	5.19842E-05	0.99964423	5.94105E-05	2.599026337	1.12631E+20	7.01097E+22	0.000304113	0.0018	0.000598807	0.78790429	0.002976072
757	7	3.23482E+18	13.39671332	5.19842E-05	0.999643903	5.94105E-05	2.599026154	1.12631E+20	7.0185E+22	0.000304439	0.0018	0.000599449	0.788748789	0.002979262
758	7	3.23482E+18	13.39670979	5.19842E-05	0.999643576	5.94105E-05	2.599025971	1.12631E+20	7.02602E+22	0.000304766	0.0018	0.000600091	0.789592835	0.00298245
759	7	3.23482E+18	13.39670626	5.19842E-05	0.99964325	5.94105E-05	2.599025788	1.12631E+20	7.03354E+22	0.000305092	0.0018	0.000600732	0.790436428	0.002985636
760	7	3.23482E+18	13.39670274	5.19841E-05	0.999642924	5.94104E-05	2.599025604	1.12631E+20	7.04106E+22	0.000305418	0.0018	0.000601372	0.791279569	0.002988821
761	7	3.23482E+18	13.39669921	5.19841E-05	0.999642597	5.94104E-05	2.599025421	1.12631E+20	7.04857E+22	0.000305744	0.0018	0.000602013	0.792122258	0.002992004
762	7	3.23482E+18	13.39669569	5.19841E-05	0.999642272	5.94104E-05	2.599025239	1.12631E+20	7.05608E+22	0.00030607	0.0018	0.000602653	0.792964495	0.002995185
763	7	3.23482E+18	13.39669217	5.19841E-05	0.999641946	5.94104E-05	2.599025056	1.12631E+20	7.06358E+22	0.000306396	0.0018	0.000603293	0.793806281	0.002998365
764	7	3.23482E+18	13.39668865	5.19841E-05	0.99964162	5.94104E-05	2.599024873	1.12631E+20	7.07109E+22	0.000306721	0.0018	0.000603932	0.794647615	0.003001543
765	7	3.23482E+18	13.39668514	5.19841E-05	0.999641295	5.94103E-05	2.59902469	1.12631E+20	7.07858E+22	0.000307046	0.0018	0.000604571	0.795488498	0.003004719
766	7	3.23482E+18	13.39668162	5.1984E-05	0.999640969	5.94103E-05	2.599024508	1.12631E+20	7.08607E+22	0.000307372	0.0018	0.00060521	0.79632893	0.003007894
767	7	3.23482E+18	13.39667811	5.1984E-05	0.999640644	5.94103E-05	2.599024325	1.12631E+20	7.09356E+22	0.000307696	0.0018	0.000605848	0.797168912	0.003011066
768	7	3.23482E+18	13.3966746	5.1984E-05	0.99964032	5.94103E-05	2.599024143	1.12631E+20	7.10105E+22	0.000308021	0.0018	0.000606486	0.798008443	0.003014237
769	7	3.23482E+18	13.39667109	5.1984E-05	0.999639995	5.94103E-05	2.599023961	1.12631E+20	7.10853E+22	0.000308346	0.0018	0.000607124	0.798847524	0.003017407
770	7	3.23482E+18	13.39666758	5.1984E-05	0.99963967	5.94102E-05	2.599023779	1.12631E+20	7.11601E+22	0.00030867	0.0018	0.000607761	0.799686156	0.003020575
771	7	3.23482E+18	13.39666408	5.19839E-05	0.999639346	5.94102E-05	2.599023597	1.12631E+20	7.12348E+22	0.000308994	0.0018	0.000608398	0.800524337	0.003023741
772	7	3.23482E+18	13.39666058	5.19839E-05	0.999639022	5.94102E-05	2.599023415	1.12631E+20	7.13095E+22	0.000309318	0.0018	0.000609035	0.80136207	0.003026905
773	7	3.23482E+18	13.39665707	5.19839E-05	0.999638698	5.94102E-05	2.599023233	1.12631E+20	7.13841E+22	0.000309642	0.0018	0.000609672	0.802199353	0.003030067
774	7	3.23482E+18	13.39665357	5.19839E-05	0.999638374	5.94102E-05	2.599023051	1.12631E+20	7.14587E+22	0.000309966	0.0018	0.000610308	0.803036187	0.003033228
775	7	3.23482E+18	13.39665008	5.19839E-05	0.99963805	5.94102E-05	2.599022869	1.1263E+20	7.15333E+22	0.00031029	0.0018	0.000610943	0.803872573	0.003036387
776	7	3.23482E+18	13.39664658	5.19839E-05	0.999637726	5.94101E-05	2.599022688	1.1263E+20	7.16078E+22	0.000310613	0.0018	0.000611578	0.80470851	0.003039545
777	7	3.23482E+18	13.39664309	5.19838E-05	0.999637403	5.94101E-05	2.599022506	1.1263E+20	7.16823E+22	0.000310936	0.0018	0.000612213	0.805543999	0.003042701
778	7	3.23482E+18	13.3966396	5.19838E-05	0.99963708	5.94101E-05	2.599022325	1.1263E+20	7.17568E+22	0.000311259	0.0018	0.000612848	0.80637904	0.003045855
779	7	3.23482E+18	13.39663611	5.19838E-05	0.999636757	5.94101E-05	2.599022144	1.1263E+20	7.18312E+22	0.000311582	0.0018	0.000613482	0.807213634	0.003049007
780	7	3.23482E+18	13.39663262	5.19838E-05	0.999636434	5.94101E-05	2.599021963	1.1263E+20	7.19056E+22	0.000311905	0.0018	0.000614116	0.80804778	0.003052158
781	7	3.23482E+18	13.39662913	5.19838E-05	0.999636111	5.941E-05	2.599021782	1.1263E+20	7.19799E+22	0.000312227	0.0018	0.00061475	0.808881479	0.003055307
782	7	3.23482E+18	13.39662565	5.19838E-05	0.999635789	5.941E-05	2.599021601	1.1263E+20	7.20542E+22	0.00031255	0.0018	0.000615383	0.809714731	0.003058454
783	7	3.23482E+18	13.39662216	5.19837E-05	0.999635467	5.941E-05	2.59902142	1.1263E+20	7.21284E+22	0.000312872	0.0018	0.000616016	0.810547536	0.0030616
784	7	3.23482E+18	13.39661868	5.19837E-05	0.999635144	5.941E-05	2.599021239	1.1263E+20	7.22027E+22	0.000313194	0.0018	0.000616649	0.811379895	0.003064744
785	7	3.23482E+18	13.3966152	5.19837E-05	0.999634822	5.941E-05	2.599021058	1.1263E+20	7.22768E+22	0.000313516	0.0018	0.000617281	0.812211808	0.003067886
786	7	3.23482E+18	13.39661173	5.19837E-05	0.999634501	5.94099E-05	2.599020878	1.1263E+20	7.2351E+22	0.000313837	0.0018	0.000617913	0.813043275	0.003071027
787	7	3.23482E+18	13.39660825	5.19837E-05	0.999634179	5.94099E-05	2.599020697	1.1263E+20	7.24251E+22	0.000314159	0.0018	0.000618544	0.813874296	0.003074166
788	7	3.23482E+18	13.39660478	5.19837E-05	0.999633858	5.94099E-05	2.599020517	1.1263E+20	7.24991E+22	0.00031448	0.0018	0.000619176	0.814704871	0.003077303
789	7	3.23482E+18	13.39660131	5.19836E-05	0.999633536	5.94099E-05	2.599020336	1.1263E+20	7.25731E+22	0.000314801	0.0018	0.000619807	0.815535001	0.003080439
790	7	3.23482E+18	13.39659784	5.19836E-05	0.999633215	5.94099E-05	2.599020156	1.1263E+20	7.26471E+22	0.000315122	0.0018	0.000620437	0.816364687	0.003083573
791	7	3.23482E+18	13.39659437	5.19836E-05	0.999632894	5.94098E-05	2.599019976	1.1263E+20	7.2721E+22	0.000315443	0.0018	0.000621067	0.817193927	0.003086705
792	7	3.23482E+18	13.3965909	5.19836E-05	0.999632573	5.94098E-05	2.599019796	1.1263E+20	7.27949E+22	0.000315764	0.0018	0.000621697	0.818022723	0.003089835
793	7	3.23482E+18	13.39658744	5.19836E-05	0.999632253	5.94098E-05	2.599019616	1.1263E+20	7.28688E+22	0.000316084	0.0018	0.000622327	0.818851075	0.003092964
794	7	3.23482E+18	13.39658397	5.19836E-05	0.999631932	5.94098E-05	2.599019436	1.1263E+20	7.29426E+22	0.000316404	0.0018	0.000622956	0.819678983	0.003096091
795	7	3.23482E+18	13.39658051	5.19835E-05	0.999631612	5.94098E-05	2.599019257	1.1263E+20	7.30164E+22	0.000316724	0.0018	0.000623585	0.820506447	0.003099217
796	7	3.23482E+18	13.39657706	5.19835E-05	0.999631292	5.94097E-05	2.599019077	1.1263E+20	7.30901E+22	0.000317044	0.0018	0.000624213	0.821333467	0.003102341
797	7	3.23482E+18	13.3965736	5.19835E-05	0.999630972	5.94097E-05	2.599018897	1.1263E+20	7.31638E+22	0.000317364	0.0018	0.000624842	0.822160044	0.003105463
798	7	3.23482E+18	13.39657014	5.19835E-05	0.999630652	5.94097E-05	2.599018718	1.1263E+20	7.32375E+22	0.000317684	0.0018	0.000625469	0.822986178	0.003108583
799	7	3.23482E+18	13.39656669	5.19835E-05	0.999630333	5.94097E-05	2.599018539	1.1263E+20	7.33111E+22	0.000318003	0.0018	0.000626097	0.823811869	0.003111702
800	7	3.23482E+18	13.39656324	5.19835E-05	0.999630013	5.94097E-05	2.599018359	1.1263E+20	7.33847E+22	0.000318323	0.0018	0.000626724	0.824637118	0.003114819
801	7	3.23482E+18	13.39655979	5.19834E-05	0.999629694	5.94097E-05	2.59901818	1.1263E+20	7.34583E+22	0.000318642	0.0018	0.000627351	0.825461924	0.003117935
802	7	3.23482E+18	13.39655634	5.19834E-05	0.999629375	5.94096E-05	2.599018001	1.12629E+20	7.35318E+22	0.000318961	0.0018	0.000627978	0.826286288	0.003121049
803	7	3.23482E+18	13.3965529	5.19834E-05	0.999629056	5.94096E-05	2.599017822	1.12629E+20	7.36052E+22	0.000319279	0.0018	0.000628604	0.827110211	0.003124161
804	7	3.23482E+18	13.39654945	5.19834E-05	0.999628737	5.94096E-05	2.599017643	1.12629E+20	7.36787E+22	0.000319598	0.0018	0.00062923	0.827933692	0.003127271
805	7	3.23482E+18	13.39654601	5.19834E-05	0.999628419	5.94096E-05	2.599017465	1.12629E+20	7.3752E+22	0.000319916	0.0018	0.000629855	0.828756731	0.00313038
806	7	3.23482E+18	13.39654257	5.19834E-05	0.9996281	5.94096E-05	2.599017286	1.12629E+20	7.38254E+22	0.000320235	0.0018	0.00063048	0.829579329	0.003133487
807	7	3.23482E+18	13.39653913	5.19833E-05	0.999627782	5.94095E-05	2.599017107	1.12629E+20	7.38987E+22	0.000320553	0.0018	0.000631105	0.830401486	0.003136592
808	7	3.23482E+18	13.39653569	5.19833E-05	0.999627464	5.94095E-05	2.599016929	1.12629E+20	7.3972E+22	0.000320871	0.0018	0.00063173	0.831223203	0.003139696
809	7	3.23482E+18	13.39653226	5.19833E-05	0.999627146	5.94095E-05	2.59901675	1.12629E+20	7.40452E+22	0.000321188	0.0018	0.000632354	0.832044479	0.003142798
810	7	3.23482E+18	13.39652883	5.19833E-05	0.999626828	5.94095E-05	2.599016572	1.12629E+20	7.41184E+22	0.000321506	0.0018	0.000632978	0.832865315	0.003145899
811	7	3.23482E+18	13.39652539	5.19833E-05	0.999626511	5.94095E-05	2.599016394	1.12629E+20	7.41916E+22	0.000321823	0.0018	0.000633601	0.833685712	0.003148998
812	7	3.23482E+18	13.39652197	5.19833E-05	0.999626193	5.94094E-05	2.599016216	1.12629E+20	7.42647E+22	0.000322141	0.0018	0.000634224	0.834505668	0.003152095
813	7	3.23482E+18	13.39651854	5.19832E-05	0.999625876	5.94094E-05	2.599016038	1.12629E+20	7.43378E+22	0.000322458	0.0018	0.000634847	0.835325185	0.00315519
814	7	3.23482E+18	13.39651511	5.19832E-05	0.999625559	5.94094E-05	2.59901586	1.12629E+20	7.44108E+22	0.000322775	0.0018	0.00063547	0.836144263	0.003158284
815	7	3.23482E+18	13.39651169	5.19832E-05	0.999625242	5.94094E-05	2.599015682	1.12629E+20	7.44838E+22	0.000323091	0.0018	0.000636092	0.836962902	0.003161376
816	7	3.23482E+18	13.39650827	5.19832E-05	0.999624926	5.94094E-05	2.599015504	1.12629E+20	7.45567E+22	0.000323408	0.0018	0.000636714	0.837781102	0.003164467
817	7	3.23482E+18	13.39650485	5.19832E-05	0.999624609	5.94094E-05	2.599015327	1.12629E+20	7.46297E+22	0.000323724	0.0018	0.000637335	0.838598863	0.003167556
818	7	3.23482E+18	13.39650143	5.19832E-05	0.999624293	5.94093E-05	2.599015149	1.12629E+20	7.47026E+22	0.00032404	0.0018	0.000637956	0.839416186	0.003170643
819	7	3.23482E+18	13.39649801	5.19831E-05	0.999623976	5.94093E-05	2.599014972	1.12629E+20	7.47754E+22	0.000324357	0.0018	0.000638577	0.840233072	0.003173728
820	7	3.23482E+18	13.3964946	5.19831E-05	0.99962366	5.94093E-05	2.599014794	1.12629E+20	7.48482E+22	0.000324672	0.0018	0.000639198	0.841049519	0.003176812
821	7	3.23482E+18	13.39649118	5.19831E-05	0.999623344	5.94093E-05	2.599014617	1.12629E+20	7.4921E+22	0.000324988	0.0018	0.000639818	0.841865529	0.003179894
822	7	3.23482E+18	13.39648777	5.19831E-05	0.999623029	5.94093E-05	2.59901444	1.12629E+20	7.49937E+22	0.000325304	0.0018	0.000640438	0.842681101	0.003182975
823	7	3.23482E+18	13.39648436	5.19831E-05	0.999622713	5.94092E-05	2.599014263	1.12629E+20	7.50664E+22	0.000325619	0.0018	0.000641057	0.843496237	0.003186054
824	7	3.23482E+18	13.39648095	5.19831E-05	0.999622398	5.94092E-05	2.599014086	1.12629E+20	7.5139E+22	0.000325934	0.0018	0.000641676	0.844310936	0.003189131
825	7	3.23482E+18	13.39647755	5.19831E-05	0.999622083	5.94092E-05	2.599013909	1.12629E+20	7.52116E+22	0.000326249	0.0018	0.000642295	0.845125198	0.003192207
826	7	3.23482E+18	13.39647414	5.1983E-05	0.999621768	5.94092E-05	2.599013732	1.12629E+20	7.52842E+22	0.000326564	0.0018	0.000642914	0.845939023	0.003195281
827	7	3.23482E+18	13.39647074	5.1983E-05	0.999621453	5.94092E-05	2.599013555	1.12629E+20	7.53568E+22	0.000326879	0.0018	0.000643532	0.846752413	0.003198353
828	7	3.23482E+18	13.39646734	5.1983E-05	0.999621138	5.94091E-05	2.599013379	1.12629E+20	7.54292E+22	0.000327194	0.0018	0.00064415	0.847565367	0.003201424
829	7	3.23482E+18	13.39646394	5.1983E-05	0.999620824	5.94091E-05	2.599013202	1.12628E+20	7.55017E+22	0.000327508	0.0018	0.000644767	0.848377885	0.003204493
830	7	3.23482E+18	13.39646055	5.1983E-05	0.999620509	5.94091E-05	2.599013026	1.12628E+20	7.55741E+22	0.000327822	0.0018	0.000645384	0.849189967	0.00320756
831	7	3.23482E+18	13.39645715	5.1983E-05	0.999620195	5.94091E-05	2.599012849	1.12628E+20	7.56465E+22	0.000328136	0.0018	0.000646001	0.850001615	0.003210626
832	7	3.23482E+18	13.39645376	5.19829E-05	0.999619881	5.94091E-05	2.599012673	1.12628E+20	7.57188E+22	0.00032845	0.0018	0.000646618	0.850812827	0.00321369
833	7	3.23482E+18	13.39645037	5.19829E-05	0.999619567	5.94091E-05	2.599012497	1.12628E+20	7.57912E+22	0.000328764	0.0018	0.000647234	0.851623605	0.003216753
834	7	3.23482E+18	13.39644698	5.19829E-05	0.999619253	5.9409E-05	2.599012321	1.12628E+20	7.58634E+22	0.000329077	0.0018	0.00064785	0.852433948	0.003219814
835	7	3.23482E+18	13.39644359	5.19829E-05	0.99961894	5.9409E-05	2.599012145	1.12628E+20	7.59356E+22	0.000329391	0.0018	0.000648465	0.853243857	0.003222873
836	7	3.23482E+18	13.3964402	5.19829E-05	0.999618626	5.9409E-05	2.599011969	1.12628E+20	7.60078E+22	0.000329704	0.0018	0.000649081	0.854053332	0.00322593
837	7	3.23482E+18	13.39643682	5.19829E-05	0.999618313	5.9409E-05	2.599011793	1.12628E+20	7.608E+22	0.000330017	0.0018	0.000649695	0.854862374	0.003228986
838	7	3.23482E+18	13.39643344	5.19828E-05	0.999618	5.9409E-05	2.599011618	1.12628E+20	7.61521E+22	0.00033033	0.0018	0.00065031	0.855670981	0.00323204
839	7	3.23482E+18	13.39643006	5.19828E-05	0.999617687	5.94089E-05	2.599011442	1.12628E+20	7.62242E+22	0.000330643	0.0018	0.000650924	0.856479156	0.003235093
840	7	3.23482E+18	13.39642668	5.19828E-05	0.999617375	5.94089E-05	2.599011267	1.12628E+20	7.62962E+22	0.000330955	0.0018	0.000651538	0.857286897	0.003238144
841	7	3.23482E+18	13.3964233	5.19828E-05	0.999617062	5.94089E-05	2.599011091	1.12628E+20	7.63682E+22	0.000331268	0.0018	0.000652152	0.858094206	0.003241193
842	7	3.23482E+18	13.39641993	5.19828E-05	0.99961675	5.94089E-05	2.599010916	1.12628E+20	7.64402E+22	0.00033158	0.0018	0.000652765	0.858901082	0.003244241
843	7	3.23482E+18	13.39641655	5.19828E-05	0.999616438	5.94089E-05	2.599010741	1.12628E+20	7.65121E+22	0.000331892	0.0018	0.000653378	0.859707526	0.003247287
844	7	3.23482E+18	13.39641318	5.19827E-05	0.999616125	5.94088E-05	2.599010566	1.12628E+20	7.6584E+22	0.000332204	0.0018	0.00065399	0.860513537	0.003250332
845	7	3.23482E+18	13.39640981	5.19827E-05	0.999615814	5.94088E-05	2.599010391	1.12628E+20	7.66558E+22	0.000332515	0.0018	0.000654603	0.861319117	0.003253375
846	7	3.23482E+18	13.39640644	5.19827E-05	0.999615502	5.94088E-05	2.599010216	1.12628E+20	7.67276E+22	0.000332827	0.0018	0.000655214	0.862124265	0.003256416
847	7	3.23482E+18	13.39640308	5.19827E-05	0.99961519	5.94088E-05	2.599010041	1.12628E+20	7.67994E+22	0.000333138	0.0018	0.000655826	0.862928982	0.003259455
848	7	3.23482E+18	13.39639971	5.19827E-05	0.999614879	5.94088E-05	2.599009866	1.12628E+20	7.68711E+22	0.00033345	0.0018	0.000656437	0.863733267	0.003262493
849	7	3.23482E+18	13.39639635	5.19827E-05	0.999614568	5.94088E-05	2.599009691	1.12628E+20	7.69428E+22	0.000333761	0.0018	0.000657048	0.864537122	0.00326553
850	7	3.23482E+18	13.39639299	5.19826E-05	0.999614257	5.94087E-05	2.599009517	1.12628E+20	7.70144E+22	0.000334072	0.0018	0.000657659	0.865340546	0.003268564
851	7	3.23482E+18	13.39638963	5.19826E-05	0.999613946	5.94087E-05	2.599009342	1.12628E+20	7.70861E+22	0.000334382	0.0018	0.000658269	0.866143539	0.003271597
852	7	3.23482E+18	13.39638627	5.19826E-05	0.999613635	5.94087E-05	2.599009168	1.12628E+20	7.71576E+22	0.000334693	0.0018	0.000658879	0.866946102	0.003274629
853	7	3.23482E+18	13.39638292	5.19826E-05	0.999613325	5.94087E-05	2.599008994	1.12628E+20	7.72292E+22	0.000335003	0.0018	0.000659489	0.867748235	0.003277659
854	7	3.23482E+18	13.39637956	5.19826E-05	0.999613014	5.94087E-05	2.59900882	1.12628E+20	7.73007E+22	0.000335313	0.0018	0.000660098	0.868549938	0.003280687

855	7	3.23482E+18	13.39637621	5.19826E-05	0.999612704	5.94086E-05	2.599008645	1.12628E+20	7.73721E+22	0.000335624	0.0018	0.000660707	0.869351212	0.003283713
856	7	3.23482E+18	13.39637286	5.19825E-05	0.999612394	5.94086E-05	2.599008471	1.12628E+20	7.74436E+22	0.000335933	0.0018	0.000661316	0.870152057	0.003286738
857	7	3.23482E+18	13.39636951	5.19825E-05	0.999612084	5.94086E-05	2.599008298	1.12627E+20	7.75149E+22	0.000336243	0.0018	0.000661924	0.870952472	0.003289762
858	7	3.23482E+18	13.39636617	5.19825E-05	0.999611774	5.94086E-05	2.599008124	1.12627E+20	7.75863E+22	0.000336553	0.0018	0.000662532	0.871752459	0.003292783
859	7	3.23482E+18	13.39636282	5.19825E-05	0.999611465	5.94086E-05	2.59900795	1.12627E+20	7.76576E+22	0.000336862	0.0018	0.00066314	0.872552017	0.003295803
860	7	3.23482E+18	13.39635948	5.19825E-05	0.999611155	5.94086E-05	2.599007776	1.12627E+20	7.77289E+22	0.000337171	0.0018	0.000663747	0.873351146	0.003298822
861	7	3.23482E+18	13.39635614	5.19825E-05	0.999610846	5.94085E-05	2.599007603	1.12627E+20	7.78001E+22	0.00033748	0.0018	0.000664354	0.874149848	0.003301839
862	7	3.23482E+18	13.3963528	5.19825E-05	0.999610537	5.94085E-05	2.599007429	1.12627E+20	7.78713E+22	0.000337789	0.0018	0.000664961	0.874948121	0.003304854
863	7	3.23482E+18	13.39634946	5.19824E-05	0.999610228	5.94085E-05	2.599007256	1.12627E+20	7.79425E+22	0.000338098	0.0018	0.000665567	0.875745967	0.003307868
864	7	3.23482E+18	13.39634613	5.19824E-05	0.999609919	5.94085E-05	2.599007083	1.12627E+20	7.80136E+22	0.000338407	0.0018	0.000666173	0.876543386	0.00331088
865	7	3.23482E+18	13.39634279	5.19824E-05	0.999609611	5.94085E-05	2.59900691	1.12627E+20	7.80847E+22	0.000338715	0.0018	0.000666779	0.877340377	0.00331389
866	7	3.23482E+18	13.39633946	5.19824E-05	0.999609302	5.94084E-05	2.599006737	1.12627E+20	7.81557E+22	0.000339023	0.0018	0.000667384	0.878136941	0.003316899
867	7	3.23482E+18	13.39633613	5.19824E-05	0.999608994	5.94084E-05	2.599006564	1.12627E+20	7.82267E+22	0.000339332	0.0018	0.000667989	0.878933079	0.003319906
868	7	3.23482E+18	13.3963328	5.19824E-05	0.999608686	5.94084E-05	2.599006391	1.12627E+20	7.82977E+22	0.000339639	0.0018	0.000668594	0.87972879	0.003322912
869	7	3.23482E+18	13.39632947	5.19823E-05	0.999608378	5.94084E-05	2.599006218	1.12627E+20	7.83686E+22	0.000339947	0.0018	0.000669198	0.880524074	0.003325916
870	7	3.23482E+18	13.39632615	5.19823E-05	0.99960807	5.94084E-05	2.599006045	1.12627E+20	7.84395E+22	0.000340255	0.0018	0.000669802	0.881318933	0.003328918
871	7	3.23482E+18	13.39632283	5.19823E-05	0.999607763	5.94084E-05	2.599005873	1.12627E+20	7.85104E+22	0.000340562	0.0018	0.000670406	0.882113366	0.003331919
872	7	3.23482E+18	13.3963195	5.19823E-05	0.999607455	5.94083E-05	2.5990057	1.12627E+20	7.85812E+22	0.00034087	0.0018	0.00067101	0.882907373	0.003334918
873	7	3.23482E+18	13.39631618	5.19823E-05	0.999607148	5.94083E-05	2.599005528	1.12627E+20	7.8652E+22	0.000341177	0.0018	0.000671613	0.883700955	0.003337915
874	7	3.23482E+18	13.39631287	5.19823E-05	0.999606841	5.94083E-05	2.599005355	1.12627E+20	7.87227E+22	0.000341484	0.0018	0.000672216	0.884494112	0.003340911
875	7	3.23482E+18	13.39630955	5.19822E-05	0.999606534	5.94083E-05	2.599005183	1.12627E+20	7.87934E+22	0.00034179	0.0018	0.000672818	0.885286844	0.003343905
876	7	3.23482E+18	13.39630623	5.19822E-05	0.999606227	5.94083E-05	2.599005011	1.12627E+20	7.88641E+22	0.000342097	0.0018	0.00067342	0.886079151	0.003346898
877	7	3.23482E+18	13.39630292	5.19822E-05	0.999605921	5.94082E-05	2.599004839	1.12627E+20	7.89347E+22	0.000342404	0.0018	0.000674022	0.886871034	0.003349889
878	7	3.23482E+18	13.39629961	5.19822E-05	0.999605614	5.94082E-05	2.599004667	1.12627E+20	7.90053E+22	0.00034271	0.0018	0.000674623	0.887662492	0.003352879
879	7	3.23482E+18	13.3962963	5.19822E-05	0.999605308	5.94082E-05	2.599004495	1.12627E+20	7.90759E+22	0.000343016	0.0018	0.000675225	0.888453527	0.003355867
880	7	3.23482E+18	13.39629299	5.19822E-05	0.999605002	5.94082E-05	2.599004323	1.12627E+20	7.91464E+22	0.000343322	0.0018	0.000675826	0.889244138	0.003358853
881	7	3.23482E+18	13.39628969	5.19821E-05	0.999604696	5.94082E-05	2.599004151	1.12627E+20	7.92168E+22	0.000343628	0.0018	0.000676426	0.890034325	0.003361838
882	7	3.23482E+18	13.39628638	5.19821E-05	0.99960439	5.94082E-05	2.59900398	1.12627E+20	7.92873E+22	0.000343933	0.0018	0.000677026	0.890824089	0.003364821
883	7	3.23482E+18	13.39628308	5.19821E-05	0.999604084	5.94081E-05	2.599003808	1.12627E+20	7.93577E+22	0.000344239	0.0018	0.000677626	0.89161343	0.003367802
884	7	3.23482E+18	13.39627978	5.19821E-05	0.999603779	5.94081E-05	2.599003637	1.12627E+20	7.94281E+22	0.000344544	0.0018	0.000678226	0.892402348	0.003370782
885	7	3.23482E+18	13.39627648	5.19821E-05	0.999603474	5.94081E-05	2.599003465	1.12626E+20	7.94984E+22	0.000344849	0.0018	0.000678825	0.893190844	0.00337376
886	7	3.23482E+18	13.39627319	5.19821E-05	0.999603169	5.94081E-05	2.599003294	1.12626E+20	7.95687E+22	0.000345154	0.0018	0.000679424	0.893978917	0.003376737
887	7	3.23482E+18	13.39626989	5.19821E-05	0.999602864	5.94081E-05	2.599003123	1.12626E+20	7.96389E+22	0.000345459	0.0018	0.000680023	0.894766568	0.003379712
888	7	3.23482E+18	13.3962666	5.1982E-05	0.999602559	5.9408E-05	2.599002952	1.12626E+20	7.97092E+22	0.000345764	0.0018	0.000680621	0.895553797	0.003382686
889	7	3.23482E+18	13.3962633	5.1982E-05	0.999602254	5.9408E-05	2.599002781	1.12626E+20	7.97793E+22	0.000346068	0.0018	0.000681219	0.896340605	0.003385658
890	7	3.23482E+18	13.39626001	5.1982E-05	0.99960195	5.9408E-05	2.59900261	1.12626E+20	7.98495E+22	0.000346373	0.0018	0.000681817	0.897126991	0.003388628
891	7	3.23482E+18	13.39625673	5.1982E-05	0.999601645	5.9408E-05	2.599002439	1.12626E+20	7.99196E+22	0.000346677	0.0018	0.000682414	0.897912956	0.003391597
892	7	3.23482E+18	13.39625344	5.1982E-05	0.999601341	5.9408E-05	2.599002269	1.12626E+20	7.99897E+22	0.000346981	0.0018	0.000683011	0.8986985	0.003394564
893	7	3.23482E+18	13.39625016	5.1982E-05	0.999601037	5.9408E-05	2.599002098	1.12626E+20	8.00597E+22	0.000347285	0.0018	0.000683608	0.899483623	0.00339753
894	7	3.23482E+18	13.39624687	5.19819E-05	0.999600733	5.94079E-05	2.599001927	1.12626E+20	8.01297E+22	0.000347589	0.0018	0.000684204	0.900268325	0.003400494
895	7	3.23482E+18	13.39624359	5.19819E-05	0.99960043	5.94079E-05	2.599001757	1.12626E+20	8.01996E+22	0.000347892	0.0018	0.0006848	0.901052608	0.003403456
896	7	3.23482E+18	13.39624031	5.19819E-05	0.999600126	5.94079E-05	2.599001587	1.12626E+20	8.02696E+22	0.000348195	0.0018	0.000685396	0.90183647	0.003406417
897	7	3.23482E+18	13.39623703	5.19819E-05	0.999599823	5.94079E-05	2.599001416	1.12626E+20	8.03394E+22	0.000348499	0.0018	0.000685991	0.902619912	0.003409376
898	7	3.23482E+18	13.39623376	5.19819E-05	0.999599519	5.94079E-05	2.599001246	1.12626E+20	8.04093E+22	0.000348802	0.0018	0.000686586	0.903402935	0.003412334
899	7	3.23482E+18	13.39623048	5.19819E-05	0.999599216	5.94078E-05	2.599001076	1.12626E+20	8.04791E+22	0.000349105	0.0018	0.000687181	0.904185538	0.00341529
900	7	3.23482E+18	13.39622721	5.19818E-05	0.999598913	5.94078E-05	2.599000906	1.12626E+20	8.05489E+22	0.000349407	0.0018	0.000687775	0.904967723	0.003418244
901	7	3.23482E+18	13.39622394	5.19818E-05	0.999598611	5.94078E-05	2.599000736	1.12626E+20	8.06186E+22	0.00034971	0.0018	0.00068837	0.905749488	0.003421197
902	7	3.23482E+18	13.39622067	5.19818E-05	0.999598308	5.94078E-05	2.599000566	1.12626E+20	8.06883E+22	0.000350012	0.0018	0.000688963	0.906530834	0.003424148
903	7	3.23482E+18	13.3962174	5.19818E-05	0.999598006	5.94078E-05	2.599000397	1.12626E+20	8.0758E+22	0.000350315	0.0018	0.000689557	0.907311762	0.003427098
904	7	3.23482E+18	13.39621414	5.19818E-05	0.999597704	5.94078E-05	2.599000227	1.12626E+20	8.08276E+22	0.000350617	0.0018	0.00069015	0.908092272	0.003430046
905	7	3.23482E+18	13.39621087	5.19818E-05	0.999597401	5.94077E-05	2.599000058	1.12626E+20	8.08972E+22	0.000350919	0.0018	0.000690743	0.908872364	0.003432993
906	7	3.23482E+18	13.39620761	5.19818E-05	0.9995971	5.94077E-05	2.598999888	1.12626E+20	8.09667E+22	0.00035122	0.0018	0.000691336	0.909652038	0.003435938
907	7	3.23482E+18	13.39620435	5.19817E-05	0.999596798	5.94077E-05	2.598999719	1.12626E+20	8.10362E+22	0.000351522	0.0018	0.000691928	0.910431295	0.003438881
908	7	3.23482E+18	13.39620109	5.19817E-05	0.999596496	5.94077E-05	2.59899955	1.12626E+20	8.11057E+22	0.000351824	0.0018	0.00069252	0.911210134	0.003441823
909	7	3.23482E+18	13.39619784	5.19817E-05	0.999596195	5.94077E-05	2.59899938	1.12626E+20	8.11751E+22	0.000352125	0.0018	0.000693111	0.911988556	0.003444763
910	7	3.23482E+18	13.39619458	5.19817E-05	0.999595893	5.94076E-05	2.598999211	1.12626E+20	8.12445E+22	0.000352426	0.0018	0.000693703	0.912766561	0.003447702
911	7	3.23482E+18	13.39619133	5.19817E-05	0.999595592	5.94076E-05	2.598999042	1.12626E+20	8.13139E+22	0.000352727	0.0018	0.000694294	0.913544149	0.003450639
912	7	3.23482E+18	13.39618808	5.19817E-05	0.999595291	5.94076E-05	2.598998873	1.12626E+20	8.13832E+22	0.000353028	0.0018	0.000694884	0.914321321	0.003453574
913	7	3.23482E+18	13.39618483	5.19816E-05	0.999594991	5.94076E-05	2.598998705	1.12626E+20	8.14525E+22	0.000353328	0.0018	0.000695475	0.915098077	0.003456508
914	7	3.23482E+18	13.39618158	5.19816E-05	0.99959469	5.94076E-05	2.598998536	1.12625E+20	8.15218E+22	0.000353629	0.0018	0.000696065	0.915874417	0.003459441
915	7	3.23482E+18	13.39617833	5.19816E-05	0.999594389	5.94076E-05	2.598998367	1.12625E+20	8.1591E+22	0.000353929	0.0018	0.000696654	0.916650341	0.003462372
916	7	3.23482E+18	13.39617509	5.19816E-05	0.999594089	5.94075E-05	2.598998199	1.12625E+20	8.16602E+22	0.000354229	0.0018	0.000697244	0.917425849	0.003465301
917	7	3.23482E+18	13.39617184	5.19816E-05	0.999593789	5.94075E-05	2.59899803	1.12625E+20	8.17293E+22	0.000354529	0.0018	0.000697833	0.918200942	0.003468229
918	7	3.23482E+18	13.3961686	5.19816E-05	0.999593489	5.94075E-05	2.598997862	1.12625E+20	8.17984E+22	0.000354829	0.0018	0.000698421	0.91897562	0.003471155
919	7	3.23482E+18	13.39616536	5.19815E-05	0.999593189	5.94075E-05	2.598997694	1.12625E+20	8.18675E+22	0.000355129	0.0018	0.00069901	0.919749883	0.003474079
920	7	3.23482E+18	13.39616212	5.19815E-05	0.999592889	5.94075E-05	2.598997525	1.12625E+20	8.19365E+22	0.000355429	0.0018	0.000699598	0.920523732	0.003477002
921	7	3.23482E+18	13.39615889	5.19815E-05	0.99959259	5.94074E-05	2.598997357	1.12625E+20	8.20055E+22	0.000355728	0.0018	0.000700186	0.921297166	0.003479924
922	7	3.23482E+18	13.39615565	5.19815E-05	0.999592291	5.94074E-05	2.598997189	1.12625E+20	8.20745E+22	0.000356027	0.0018	0.000700773	0.922070186	0.003482844
923	7	3.23482E+18	13.39615242	5.19815E-05	0.999591991	5.94074E-05	2.598997021	1.12625E+20	8.21434E+22	0.000356326	0.0018	0.000701361	0.922842792	0.003485762
924	7	3.23482E+18	13.39614919	5.19815E-05	0.999591692	5.94074E-05	2.598996854	1.12625E+20	8.22123E+22	0.000356625	0.0018	0.000701947	0.923614985	0.003488679
925	7	3.23482E+18	13.39614596	5.19815E-05	0.999591393	5.94074E-05	2.598996686	1.12625E+20	8.22811E+22	0.000356924	0.0018	0.000702534	0.924386763	0.003491594
926	7	3.23482E+18	13.39614273	5.19814E-05	0.999591095	5.94074E-05	2.598996518	1.12625E+20	8.235E+22	0.000357222	0.0018	0.00070312	0.925158129	0.003494507
927	7	3.23482E+18	13.39613951	5.19814E-05	0.999590796	5.94073E-05	2.598996351	1.12625E+20	8.24187E+22	0.000357521	0.0018	0.000703706	0.925929081	0.003497419
928	7	3.23482E+18	13.39613628	5.19814E-05	0.999590498	5.94073E-05	2.598996183	1.12625E+20	8.24875E+22	0.000357819	0.0018	0.000704292	0.926699621	0.00350033
929	7	3.23482E+18	13.39613306	5.19814E-05	0.999590199	5.94073E-05	2.598996016	1.12625E+20	8.25562E+22	0.000358117	0.0018	0.000704877	0.927469748	0.003503239
930	7	3.23482E+18	13.39612984	5.19814E-05	0.999589901	5.94073E-05	2.598995848	1.12625E+20	8.26248E+22	0.000358415	0.0018	0.000705462	0.928239462	0.003506146
931	7	3.23482E+18	13.39612662	5.19814E-05	0.999589603	5.94073E-05	2.598995681	1.12625E+20	8.26935E+22	0.000358713	0.0018	0.000706047	0.929008765	0.003509052
932	7	3.23482E+18	13.3961234	5.19813E-05	0.999589306	5.94073E-05	2.598995514	1.12625E+20	8.27621E+22	0.000359011	0.0018	0.000706631	0.929777655	0.003511956
933	7	3.23482E+18	13.39612019	5.19813E-05	0.999589008	5.94072E-05	2.598995347	1.12625E+20	8.28306E+22	0.000359308	0.0018	0.000707215	0.930546134	0.003514859
934	7	3.23482E+18	13.39611697	5.19813E-05	0.999588711	5.94072E-05	2.59899518	1.12625E+20	8.28991E+22	0.000359605	0.0018	0.000707799	0.931314201	0.00351776
935	7	3.23482E+18	13.39611376	5.19813E-05	0.999588413	5.94072E-05	2.598995013	1.12625E+20	8.29676E+22	0.000359903	0.0018	0.000708382	0.932081857	0.00352066
936	7	3.23482E+18	13.39611055	5.19813E-05	0.999588116	5.94072E-05	2.598994847	1.12625E+20	8.30361E+22	0.0003602	0.0018	0.000708965	0.932849102	0.003523558
937	7	3.23482E+18	13.39610734	5.19813E-05	0.999587819	5.94072E-05	2.59899468	1.12625E+20	8.31045E+22	0.000360496	0.0018	0.000709548	0.933615937	0.003526454
938	7	3.23482E+18	13.39610413	5.19813E-05	0.999587522	5.94071E-05	2.598994513	1.12625E+20	8.31729E+22	0.000360793	0.0018	0.000710131	0.93438236	0.003529349
939	7	3.23482E+18	13.39610093	5.19812E-05	0.999587226	5.94071E-05	2.598994347	1.12625E+20	8.32412E+22	0.00036109	0.0018	0.000710713	0.935148373	0.003532242
940	7	3.23482E+18	13.39609773	5.19812E-05	0.999586929	5.94071E-05	2.59899418	1.12625E+20	8.33095E+22	0.000361386	0.0018	0.000711295	0.935913976	0.003535134
941	7	3.23482E+18	13.39609452	5.19812E-05	0.999586633	5.94071E-05	2.598994014	1.12625E+20	8.33778E+22	0.000361682	0.0018	0.000711876	0.936679169	0.003538025
942	7	3.23482E+18	13.39609132	5.19812E-05	0.999586337	5.94071E-05	2.598993848	1.12625E+20	8.3446E+22	0.000361978	0.0018	0.000712457	0.937443953	0.003540913
943	7	3.23482E+18	13.39608813	5.19812E-05	0.99958604	5.94071E-05	2.598993682	1.12624E+20	8.35142E+22	0.000362274	0.0018	0.000713038	0.938208327	0.0035438
944	7	3.23482E+18	13.39608493	5.19812E-05	0.999585745	5.9407E-05	2.598993516	1.12624E+20	8.35823E+22	0.00036257	0.0018	0.000713619	0.938972291	0.003546686
945	7	3.23482E+18	13.39608173	5.19811E-05	0.999585449	5.9407E-05	2.59899335	1.12624E+20	8.36505E+22	0.000362866	0.0018	0.000714199	0.939735847	0.00354957
946	7	3.23482E+18	13.39607854	5.19811E-05	0.999585153	5.9407E-05	2.598993184	1.12624E+20	8.37186E+22	0.000363161	0.0018	0.000714779	0.940498993	0.003552453
947	7	3.23482E+18	13.39607535	5.19811E-05	0.999584858	5.9407E-05	2.598993018	1.12624E+20	8.37866E+22	0.000363456	0.0018	0.000715359	0.941261732	0.003555334
948	7	3.23482E+18	13.39607216	5.19811E-05	0.999584563	5.9407E-05	2.598992852	1.12624E+20	8.38546E+22	0.000363751	0.0018	0.000715938	0.942024061	0.003558213
949	7	3.23482E+18	13.39606897	5.19811E-05	0.999584268	5.9407E-05	2.598992687	1.12624E+20	8.39226E+22	0.000364046	0.0018	0.000716517	0.942785983	0.003561091
950	7	3.23482E+18	13.39606578	5.19811E-05	0.999583973	5.94069E-05	2.598992521	1.12624E+20	8.39905E+22	0.000364341	0.0018	0.000717096	0.943547497	0.003563968
951	7	3.23482E+18	13.3960626	5.19811E-05	0.999583678	5.94069E-05	2.598992356	1.12624E+20	8.40584E+22	0.000364636	0.0018	0.000717675	0.944308603	0.003566842
952	7	3.23482E+18	13.39605941	5.1981E-05	0.999583383	5.94069E-05	2.59899219	1.12624E+20	8.41263E+22	0.00036493	0.0018	0.000718253	0.945069301	0.003569716
953	7	3.23482E+18	13.39605623	5.1981E-05	0.999583089	5.94069E-05	2.598992025	1.12624E+20	8.41941E+22	0.000365225	0.0018	0.00071883	0.945829592	0.003572588
954	7	3.23482E+18	13.39605305	5.1981E-05	0.999582794	5.94069E-05	2.59899186	1.12624E+20	8.42619E+22	0.000365519	0.0018	0.000719408	0.946589476	0.003575458
955	7	3.23482E+18	13.39604987	5.1981E-05	0.9995825	5.94068E-05	2.598991695	1.12624E+20	8.43297E+22	0.000365813	0.0018	0.000719985	0.947348954	0.003578326
956	7	3.23482E+18	13.3960467	5.1981E-05	0.999582206	5.94068E-05	2.59899153	1.12624E+20	8.43974E+22	0.000366107	0.0018	0.000720562	0.948108024	0.003581194
957	7	3.23482E+18	13.39604352	5.1981E-05	0.999581912	5.94068E-05	2.598991365	1.12624E+20	8.44651E+22	0.0003664	0.0018	0.000721139	0.948866689	0.003584059
958	7	3.23482E+18	13.39604035	5.19809E-05	0.999581619	5.94068E-05	2.5989912	1.12624E+20	8.45328E+22	0.000366694	0.0018	0.000721715	0.949624947	0.003586923
959	7	3.23482E+18	13.39603718	5.19809E-05	0.999581325	5.94068E-05	2.598991035	1.12624E+20	8.46004E+22	0.000366987	0.0018	0.000722291	0.950382799	0.003589786
960	7	3.23482E+18	13.39603401	5.19809E-05	0.999581032	5.94068E-05	2.598990871	1.12624E+20	8.46679E+22	0.000367281	0.0018	0.000722867	0.951140246	0.003592647
961	7	3.23482E+18	13.39603084	5.19809E-05	0.999580739	5.94067E-05	2.598990706	1.12624E+20	8.47355E+22	0.000367574	0.0018	0.000723442	0.951897286	0.003595506
962	7	3.23482E+18	13.39602767	5.19809E-05	0.999580445	5.94067E-05	2.598990542	1.12624E+20	8.4803E+22	0.000367867	0.0018	0.000724017	0.952653922	0.003598364
963	7	3.23482E+18	13.39602451	5.19809E-05	0.999580153	5.94067E-05	2.598990377	1.12624E+20	8.48705E+22	0.000368159	0.0018	0.000724592	0.953410153	0.003601221
964	7	3.23482E+18	13.39602135	5.19809E-05	0.99957986	5.94067E-05	2.598990213	1.12624E+20	8.49379E+22	0.000368452	0.0018	0.000725166	0.954165979	0.003604076
965	7	3.23482E+18	13.39601819	5.19808E-05	0.999579567	5.94067E-05	2.598990049	1.12624E+20	8.50053E+22	0.000368744	0.0018	0.00072574	0.9549214	0.003606929
966	7	3.23482E+18	13.39601503	5.19808E-05	0.999579275	5.94067E-05	2.598989885	1.12624E+20	8.50727E+22	0.000369037	0.0018	0.000726314	0.955676416	0.003609781
967	7	3.23482E+18	13.39601187	5.19808E-05	0.999578982	5.94066E-05	2.598989721	1.12624E+20	8.514E+22	0.000369329	0.0018	0.000726888	0.956431029	0.003612631
968	7	3.23482E+18	13.39600871	5.19808E-05	0.99957869	5.94066E-05	2.598989557	1.12624E+20	8.52073E+22	0.000369621	0.0018	0.000727461	0.957185238	0.00361548
969	7	3.23482E+18	13.39600556	5.19808E-05	0.999578398	5.94066E-05	2.598989393	1.12624E+20	8.52745E+22	0.000369913	0.0018	0.000728034	0.957939042	0.003618327
970	7	3.23482E+18	13.3960024	5.19808E-05	0.999578107	5.94066E-05	2.598989229	1.12624E+20	8.53418E+22	0.000370204	0.0018	0.000728606	0.958692444	0.003621173
971	7	3.23482E+18	13.39599925	5.19807E-05	0.999577815	5.94066E-05	2.598989065	1.12624E+20	8.5409E+22	0.000370496	0.0018	0.000729179	0.959445442	0.003624017
972	7	3.23482E+18	13.3959961	5.19807E-05	0.999577523	5.94066E-05	2.598988902	1.12624E+20	8.54761E+22	0.000370787	0.0018	0.000729751	0.960198036	0.00362686
973	7	3.23482E+18	13.39599296	5.19807E-05	0.999577232	5.94065E-05	2.598988738	1.12623E+20	8.55432E+22	0.000371079	0.0018	0.000730322	0.960950228	0.003629701
974	7	3.23482E+18	13.39598981	5.19807E-05	0.999576941	5.94065E-05	2.598988575	1.12623E+20	8.56103E+22	0.00037137	0.0018	0.000730894	0.961702018	0.003632541
975	7	3.23482E+18	13.39598666	5.19807E-05	0.99957665	5.94065E-05	2.598988411	1.12623E+20	8.56773E+22	0.000371661	0.0018	0.000731465	0.962453405	0.003635379
976	7	3.23482E+18	13.39598352	5.19807E-05	0.999576359	5.94065E-05	2.598988248	1.12623E+20	8.57443E+22	0.000371951	0.0018	0.000732035	0.963204389	0.003638216
977	7	3.23482E+18	13.39598038	5.19807E-05	0.999576068	5.94065E-05	2.598988085	1.12623E+20	8.58113E+22	0.000372242	0.0018	0.000732606	0.963954972	0.003641051
978	7	3.23482E+18	13.39597724	5.19806E-05	0.999575777	5.94064E-05	2.598987922	1.12623E+20	8.58783E+22	0.000372532	0.0018	0.000733176	0.964705153	0.003643884
979	7	3.23482E+18	13.3959741	5.19806E-05	0.999575487	5.94064E-05	2.598987759	1.12623E+20	8.59452E+22	0.000372823	0.0018	0.000733746	0.965454932	0.003646716
980	7	3.23482E+18	13.39597097	5.19806E-05	0.999575197	5.94064E-05	2.598987596	1.12623E+20	8.6012E+22	0.000373113	0.0018	0.000734315	0.96620431	0.003649547
981	7	3.23482E+18	13.39596783	5.19806E-05	0.999574907	5.94064E-05	2.598987433	1.12623E+20	8.60788E+22	0.000373403	0.0018	0.000734884	0.966953287	0.003652376
982	7	3.23482E+18	13.3959647	5.19806E-05	0.999574617	5.94064E-05	2.59898727	1.12623E+20	8.61456E+22	0.000373693	0.0018	0.000735453	0.967701863	0.003655203

983	7	3.23482E+18	13.39596157	5.19806E-05	0.999574327	5.94064E-05	2.598987108	1.12623E+20	8.62124E+22	0.000373982	0.0018	0.000736022	0.968450038	0.003658029
984	7	3.23482E+18	13.39595844	5.19806E-05	0.999574037	5.94063E-05	2.598986945	1.12623E+20	8.62791E+22	0.000374272	0.0018	0.00073659	0.969197813	0.003660854
985	7	3.23482E+18	13.39595531	5.19805E-05	0.999573748	5.94063E-05	2.598986783	1.12623E+20	8.63458E+22	0.000374561	0.0018	0.000737158	0.969945188	0.003663677
986	7	3.23482E+18	13.39595218	5.19805E-05	0.999573458	5.94063E-05	2.59898662	1.12623E+20	8.64125E+22	0.00037485	0.0018	0.000737726	0.970692162	0.003666498
987	7	3.23482E+18	13.39594906	5.19805E-05	0.999573169	5.94063E-05	2.598986458	1.12623E+20	8.64791E+22	0.000375139	0.0018	0.000738293	0.971438737	0.003669318
988	7	3.23482E+18	13.39594594	5.19805E-05	0.99957288	5.94063E-05	2.598986296	1.12623E+20	8.65457E+22	0.000375428	0.0018	0.000738861	0.972184912	0.003672137
989	7	3.23482E+18	13.39594282	5.19805E-05	0.999572591	5.94063E-05	2.598986134	1.12623E+20	8.66122E+22	0.000375717	0.0018	0.000739427	0.972930688	0.003674954
990	7	3.23482E+18	13.3959397	5.19805E-05	0.999572302	5.94062E-05	2.598985972	1.12623E+20	8.66787E+22	0.000376006	0.0018	0.000739994	0.973676064	0.003677769
991	7	3.23482E+18	13.39593658	5.19804E-05	0.999572014	5.94062E-05	2.59898581	1.12623E+20	8.67452E+22	0.000376294	0.0018	0.00074056	0.974421042	0.003680583
992	7	3.23482E+18	13.39593346	5.19804E-05	0.999571725	5.94062E-05	2.598985648	1.12623E+20	8.68116E+22	0.000376582	0.0018	0.000741126	0.97516562	0.003683396
993	7	3.23482E+18	13.39593035	5.19804E-05	0.999571437	5.94062E-05	2.598985486	1.12623E+20	8.6878E+22	0.000376871	0.0018	0.000741691	0.975909801	0.003686206
994	7	3.23482E+18	13.39592723	5.19804E-05	0.999571149	5.94062E-05	2.598985324	1.12623E+20	8.69444E+22	0.000377159	0.0018	0.000742257	0.976653582	0.003689016
995	7	3.23482E+18	13.39592412	5.19804E-05	0.999570861	5.94062E-05	2.598985163	1.12623E+20	8.70107E+22	0.000377446	0.0018	0.000742822	0.977396966	0.003691824
996	7	3.23482E+18	13.39592101	5.19804E-05	0.999570573	5.94061E-05	2.598985001	1.12623E+20	8.7077E+22	0.000377734	0.0018	0.000743386	0.978139952	0.00369463
997	7	3.23482E+18	13.39591791	5.19804E-05	0.999570286	5.94061E-05	2.59898484	1.12623E+20	8.71433E+22	0.000378022	0.0018	0.000743951	0.978882541	0.003697435
998	7	3.23482E+18	13.3959148	5.19803E-05	0.999569998	5.94061E-05	2.598984678	1.12623E+20	8.72095E+22	0.000378309	0.0018	0.000744515	0.979624731	0.003700239
999	7	3.23482E+18	13.39591169	5.19803E-05	0.999569711	5.94061E-05	2.598984517	1.12623E+20	8.72757E+22	0.000378596	0.0018	0.000745079	0.980366525	0.00370304
1000	7	3.23482E+18	13.39590859	5.19803E-05	0.999569423	5.94061E-05	2.598984356	1.12623E+20	8.73419E+22	0.000378883	0.0018	0.000745642	0.981107922	0.003705841
								8.976983959	6.956960938					2.020023021
								total O3 (gram) produced	total O3 (gram) remained in PS					total O3 boiled off (gram)

Lessard, Edward T

From: Lessard, Edward T
Sent: Wednesday, January 21, 2004 9:04 AM
To: Travis, Richard J
Cc: Meng, Wuzheng; Phillips, David B; Kane, Steven F; Iarocci, Michael
Subject: FW: LESHC 04-02, MECO Magnet Draft SOW/Spec Review

MECO Magnet SOW and Tech Spec ...

Hi Travis:

Ralph Brown is an engineer at STAR. I am not sure how he might be involved. At any rate, C-AD has some Seismic Hazard Guidance at
http://www.rhichome.bnl.gov/AGS/Accel/SND/info.htm

I will forward this email to Wuzheng Meng and Dave Phillips who are the C-AD Liaison Physicist and Liaison Engineer for MECO, respectively.

Ed

-----Original Message-----
From: Travis, Richard J
Sent: Wednesday, January 21, 2004 8:17 AM
To: Lessard, Edward T
Cc: Travis, Richard J
Subject: FW: LESHC 04-02, MECO Magnet Draft SOW/Spec Review

Ed,
Who is Ralph Brown and is he reviewing this spec via another mechanism? Rich

-----Original Message-----
From: Kane, Steven F
Sent: Tuesday, January 20, 2004 6:27 PM
To: Travis, Richard J; Mike Iarocci (E-mail)
Cc: Lessard, Edward T
Subject: RE: LESHC 04-02, MECO Magnet Draft SOW/Spec Review

My comments are attached. I put in something about heat load analysis, but Mike can do a better job of describing it than I. Also, Ralph Brown should be able to provide the seismic specs

-----Original Message-----
From: Travis, Richard J
Sent: Tuesday, January 13, 2004 7:13 PM
To: Alforque, Rodulfo; Glenn, Joseph W; Iarocci, Michael; Kane, Steven F; Kroon, Peter J; Mortazavi, Payman; Rehak, Margareta L; Sidi-Yekhlef, Ahmed; Wu, Kuo-Chen
Cc: Lessard, Edward T; Ellerkamp, John J; Greves, Linda E; Travis, Richard J
Subject: LESHC 04-02, MECO Magnet Draft SOW/Spec Review

All,
Ed asked me to followup and to let everyone know that we would like your comments by COB Tuesday 1/20. Please send your input to me, with a copy to Ed. Thanks, Rich

-----Original Message-----
From: Lessard, Edward T
Sent: Thursday, January 08, 2004 11:46 AM

To: Kane, Steven F; Wu, Kuo-Chen; Glenn, Joseph W; Iarocci, Michael; Travis, Richard J; Kroon, Peter J; Rehak, Margareta L; Mortazavi, Payman; Sidi-Yekhlef, Ahmed; Alforque, Rodulfo
Cc: 'wmolzen@uci.edu'
Subject: FW: MECO Magnet Draft SOW/Spec

Hi Folks:

Please look at this Design Spec for the MECO Superconducting magnet. I believe the Cryogenic Safety Committee asked to be involved at the design spec phase so here is your opportunity to speak up if you see anything you interesting.

Thanks.

Ed